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COMPARATIVE TESTS ON DIFFERENT FORMS OF CEMENT BRIQUETTES.

BY PROF. JEROME SONDERICKER, MEMBER OF THE BOSTON SOCIETY OF
CIVIL ENGINEERS.

[Read before the Society December 21, 1898.*]

THE circular recently issued by the Committee of the American Society of Civil Engineers on Tests of Cement reopens questions concerning the relative merits of different forms of briquette, distance between bearing points and the like. In order to secure more definite information in these directions Mr. Henry C. Belcher, Class of 1898, M. I. T., undertook for his graduating thesis to make comparative tests on different forms of briquette. The thesis included the selection of the forms of briquette to be tested, the design of special clips for the tests and the tests themselves. The forms of briquette selected are shown in Fig. 1. In A the dotted lines indicate the form in use at M. I. T. This form was elongated in order to secure a length between gripping points up to 3 inches. Both are included under the letter A. B is similar to A, but with more flaring sides, the slope of the tangents being $1\frac{1}{2}$ to 1. It differs from the form suggested by Mr. L. C. Sabin (see *Municipal Engineering*, February, 1897, p. 77) only in the radius at the center being 1 inch instead of $\frac{3}{4}$ inch. It is also elongated. C is a modification of the German standard, which is shown in Fig. 2 for comparison. The section was altered to 1 square inch, and it was made of the same length as A and B. C is also similar to a form understood to have been proposed by Prof. J. B. Johnson. D is the A. S. C. E. standard form.

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Fig. 3 is a drawing of the clips, also taken from Mr. Belcher's thesis. Double knife edges were used to secure a central pull. These are not shown in the drawing. The side guides are used to hold the clips in position while inserting the briquette. This device was described in my paper on cement testing published in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES for June, 1888; also in the "Transactions of the American Society of Mechanical Engineers," Vol. IX. The rounded gripping points

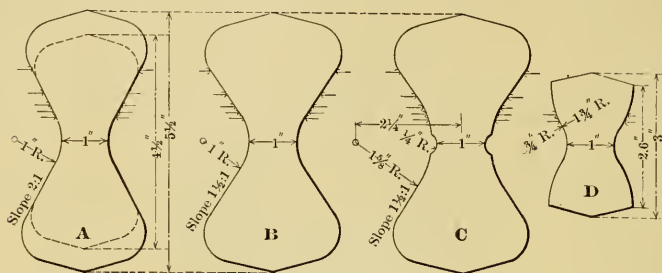
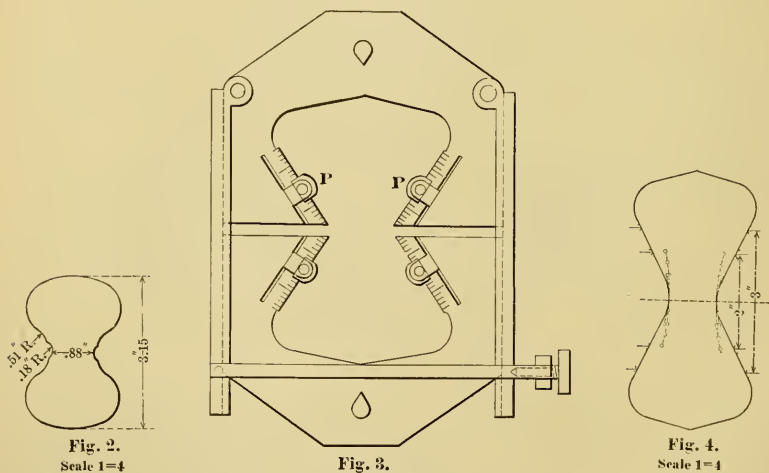


Fig. 1. Scale 1=4



have radii of 9-32 and $2\frac{1}{2}$ inches respectively, parallel and at right angles to the face of the clips. These points slide on the inner surfaces of the clips, and can be set in any position by means of the graduations. They are held in place by springs on each side, engaging the grooves shown in the drawing. With this arrangement all the forms of briquette could be broken, and the length between gripping points varied from 1 to 3 inches. The length of specimen always means the distance between the gripping points of the two clips, and not the distance between the gripping points

of the same clips, which will be referred to as the width between gripping points. These widths for different lengths of specimen are given in Table I.

TABLE I.

Length of Specimen.	Width between Gripping Points.			
	A	B	C	D
1"	1.26"	1.27"	1.41"	1.36"
1 $\frac{1}{4}$ "	1.39"	1.43"	1.50"	1 48"
1 $\frac{1}{2}$ "	1.51"	1.59"	1.62"	
2"	1.76"	1.93"	1.93"	
3"	2.26"	2.59"	2.59"	

The moulds used were divided into sets of four, and included three sets of A (short), one set of A (long) and one set each of B, C and D, twenty-eight moulds altogether.

The general plan was to fill all the moulds with one mixing and break all the briquettes of any one mixing at the same time. In testing each of the larger sets the four briquettes were broken with different lengths of specimen, namely, 1, 1 $\frac{1}{4}$, 2 and 3 inches. In each of the short A sets the lengths were 1, 1 $\frac{1}{4}$, 1 $\frac{1}{2}$ and 2 inches. In each of the D sets the lengths were 1 and 1 $\frac{1}{4}$ inches (two briquettes each). These lengths are shown in Fig. 1. We had thus the means for determining the variation of strength with length of specimen for each form of briquette, and also the relative strength of the different forms. Mr. Belcher's time permitted his testing only a small number of briquettes, and the results obtained were not conclusive. For this reason I undertook experiments under the plans outlined above. The results will now be presented.

Four hundred and eighty-eight briquettes were broken, including Portland cement, neat and three parts sand to one cement; and Rosendale cement, neat and one part sand to one cement. Part of these were broken after about one week, and the remainder after about four months.

I. VARIATION OF STRENGTH WITH LENGTH OF SPECIMEN BETWEEN GRIPPING POINTS.

To determine this the breaking strengths of the individual briquettes in each set of four were expressed in percentages, calling the strength of the one broken with a length of 1 inch 100. The average of these percentages was then taken in various ways, as indicated in the first column of Table II, where the results are recorded. The figures in parenthesis are the number of tests averaged, and will give an indication of the reliability of the aver-

ages. Although some of the briquettes were obviously imperfect, all are included in these averages with the exception of five which broke by a corner of the head shearing off.

From the results given in Table II it would seem that for neat cement briquettes the tensile strength increases with the length of specimen, the rate of increase being shown in the second line of the table. The results for both long and short time tests, Portland and Rosendale cement, and for each of the different forms of briquette, agree with this conclusion.

TABLE II.

Comparative tensile strength of briquettes broken with different lengths between gripping points. Strength for 1-inch length, 100.

Tests Averaged.	Length between Gripping Points.			
	1¼"	1½"	2"	3"
All.....	107 (61)	108 (97)	112 (104)	118 (60)
All neat cement.....	108 (50)	110 (78)	115 (84)	123 (50)
Neat Portland, 1 week old.....	110 (19)	111 (30)	118 (31)	122 (17)
Neat Portland, 4 months old.....	102 (8)	112 (12)	111 (12)	126 (6)
All neat Portland.....	108 (27)	111 (42)	116 (43)	123 (23)
Neat Rosendale, 1 week old.....	110 (15)	109 (25)	113 (29)	123 (21)
Neat Rosendale, 4 months old.....	106 (8)	106 (11)	113 (12)	124 (6)
All neat Rosendale.....	108 (23)	108 (36)	113 (41)	123 (27)
Forms A (long), B, C, neat.....	.....	111 (50)	114 (50)	123 (50)
Form A (short), neat.....	108 (34)	108 (34)	117 (34)	.....
Form A (long), neat.....	.....	110 (16)	115 (16)	121 (16)
Form B, neat.....	.....	113 (16)	108 (16)	127 (16)
Form C, neat.....	.....	109 (17)	113 (17)	116 (17)
Form D, neat.....	107 (16)	.....	.....	.....
All sand mortars.....	103 (11)	103 (19)	101 (20)	95 (10)
All 3 sand, 1 cement, Portland.....	105 (3)	98 (8)	102 (8)	101 (4)
All 1 sand, 1 cement, Rosendale.....	102 (8)	106 (11)	101 (12)	90 (6)
Forms A (long), B, C, sand mortars...	.....	96 (11)	95 (11)	95 (11)
Form A (short), sand mortars.....	103 (8)	112 (2)	111 (8)	.....
Form A (long), sand mortars.....	.....	100 (4)	90 (4)	99 (4)
Form B, sand mortars.....	.....	89 (3)	100 (3)	96 (3)
Form C, sand mortars.....	.....	96 (4)	94 (4)	91 (4)
Form D, sand mortars.....	104 (4)	.....	.....	.....

In case of the sand mortars tested the strength appears to be nearly independent of the length of specimen. A greater number of tests are needed to confirm this result.

II. RELATIVE STRENGTH OF DIFFERENT FORMS OF BRIQUETTE.

The strengths of the different forms of briquette were compared, making the comparison only between briquettes having the same length between gripping points. For this purpose Form A was taken as standard, and the strengths of the other forms for any one mixing expressed in per cent. of the strength of A. The

average results obtained by this comparison are given in Table III. As in Table II, the sand mortars are the average of a comparatively small number of tests. From Table III it appears that, for the same length of specimen, A, B and D give about the same strength, B falling a trifle below A and D. The results for B are also some-

TABLE III.

Comparative strength of different forms of briquette.

Tests Averaged.	A	B	C	D
All.....	100	98.4	87.0	100.0
All neat cement.....	100	100.6	87.2	98.9
Portland, 1 week old, neat.	100	98.8	83.9	101.2
Portland, 4 months old, neat.....	100	99.3	91.0	102.9
Rosendale, 1 week old, neat.	100	105.6	90.1	96.0
Rosendale, 4 months old, neat.....	100	89.2	84.0	94.6
All sand mortars.....	100	88.6	86.2	104.8
Portland, sand 3, cement 1.....	100	92.5	89.8	100.3
Rosendale, sand 1, cement 1.....	100	85.2	83.0	108.2

what irregular. C gives uniformly a lower strength than the others—about 13 per cent. on the average. This conclusion is true for neat cement, and, with the exception of B, for sand mortars. The averages for each distance between gripping points agree with the general averages given in the first line of Table III. These separate averages are given in Table IV.

TABLE IV.

Comparative strength of different forms of briquette for each length of specimen between gripping points.

	Length between Gripping Points.				
	1"	1¼"	1½"	2"	3"
Form A	100	100	100	100	100
Form B.....	98.9	.....	96.3	94.0	105.2
Form C.....	89.6	.....	87.7	87.5	83.3
Form D.....	100.6	99.4	.....	.....	.....

III. PERCENTAGE OF FRACTURES NOT AT SMALLEST SECTION.

The areas of the sections at which the fractures occurred were determined in order to make a comparison between the different forms of briquette and different lengths of specimens in this respect. For this purpose the fractures were grouped into those where the fractured area exceeded the area of the smallest section (1 square inch) by the following amounts: 1 by less than 5 per cent.; 2 between 5 and 10 per cent.; 3 by more than 10

per cent. The percentage of fractures for each length of specimen falling within these limits is given in Table V. In Form C all the briquettes broke within the notch, but not at its center. The section at the edge of the notch is 1.25 inch. As only two bri-

TABLE V.

Percentage of fractures falling within the limits stated in first column.

Excess of Area.	Form.	Length between Gripping Points.				
		1"	1½"	1½"	2"	3"
Less than 5 per cent.	A	90.5	83.4	85.0	75.8	85.0
	B	90.0	.....	93.7	76.2	78.9
	C	95.2	.....	100.0	85.7	95.2
	D	95.0	72.3	.....	.....	.....
Between 5 per cent. and 10 per cent.	A	4.8	14.3	11.7	17.7	10.0
	B	10.0	.....	6.3	14.3	10.5
	C	4.8	.....	0	9.5	4.8
	D	5.0	16.7	.....	.....	.....
Above 10 per cent.	A	4.8	2.4	3.3	6.4	5.0
	B	0	.....	0	9.5	10.5
	C	0	.....	0	4.8	0
	D	0	11.1	.....	.....	.....

quettes of the other forms broke where the area was greater than 1.25 inch, the behavior of C in this respect is not remarkable. The notch, however, would explain the somewhat higher percentage of center fractures for this form.

From Table V we conclude that the number of fractures away from the smallest section is not influenced materially by the length of specimen, and is about the same for Forms A, B and D. If we compare the different forms of briquette without reference to the length of specimen we find the following percentages of fractures at sections where the excess of area is less than 5 per cent: A, 83.9 per cent.; B, 84.2 per cent.; C, 94.0 per cent.; D, 84.3 per cent.

A similar comparison for sand mortars alone gives the following results: A, 91.1 per cent.; B, 100 per cent.; C, 100 per cent.; D, 92.9 per cent.

Of the eighty-nine sand mortar briquettes only five broke where the excess of area was 5 per cent. or more, the greatest excess being 6.8 per cent. Although the gripping points were quite sharply rounded, out of the total of 488 briquettes broken only two broke at the gripping points; these two were of Form A, with 1 inch length between gripping points. Five broke by shear-

ing off a corner of the head, namely, three D's, $1\frac{1}{4}$ -inch length; one A, 3-inch length, and one B, 3-inch length. This discussion has no reference to clip breaks. With properly designed moulds and clips there should be no breaks at the gripping points.

IV. RELATION BETWEEN POSITION OF FRACTURE AND STRENGTH OF BRIQUETTE.

The breaking strengths of each set of four briquettes were graded, calling the lowest one and the highest four. Of the sixty-five briquettes which broke outside the 5 per cent. limit, there were eleven ones, fourteen twos, sixteen threes and twenty-four fours. This shows that the strongest briquettes are most likely to break out of the smallest section. Of the five sand mortar briquettes which broke beyond the 5 per cent. limit, there were two ones, one two and two fours.

V. CAUSE OF NON-CENTRAL FRACTURES, AND THEIR CONNECTION WITH THE FORM OF THE BRIQUETTE.

In order to discuss this matter refer to the second line of Table II. The strength for 1 inch length is 100. Let us take this to represent, roughly, the strength per square inch of a briquette at a point $\frac{1}{2}$ inch from the gripping points. Similarly take 108 to represent the strength per square inch at $\frac{5}{8}$ inch from the gripping points, etc. If now the length of specimen is 3 inches, the numbers 100, 108, 110, 115 and 123 may be taken to represent roughly the relative strength per square inch at distances of $\frac{1}{2}$ inch, $\frac{5}{8}$ inch, $\frac{3}{4}$ inch, 1 inch and $1\frac{1}{2}$ inches from the gripping points. In order for the briquette to be equally liable to break at these different sections, then, the areas of these sections must be inversely proportional to the relative strengths stated above. For example, in the case assumed the width of the briquette at a point $\frac{1}{2}$ inch distance from the gripping points would have to be 1.23 inches in order for the briquette to be equally liable to break at this point and at the middle. In this manner the widths at different distances from the gripping points, necessary in order that a briquette of neat cement would be equally liable to break at all sections, were calculated. The results for lengths between gripping points of 2 and 3 inches are plotted in Fig. 4. The longer curve corresponds to the 3-inch length. These curves would then represent the outline of a briquette of equal strength for the lengths between gripping points stated. Form A is drawn for comparison. From this diagram it appears probable that the excess of strength for sections near the middle is very small. Take the 2-inch length,

for example. At $\frac{1}{4}$ inch from the smallest section the width of the briquette is 1.06 inches, and the width necessary for equal strength is 1.045 inches, so there is an excess of width at this point of .015 inch. At $\frac{1}{2}$ inch distance the width of the briquette is 1.26 inches, and the width necessary for equal strength 1.15 inches, leaving an excess of width of .11 inch. Of the eighty-two briquettes of Forms A and B (B near the middle has the same outline as A) broken with a length of 2 inches, sixty-six broke within $\frac{1}{4}$ inch of the middle, —*i.e.*, where the excess of section over that necessary for equal strength, according to the above estimate, was less than .015 inch; and the remaining sixteen briquettes broke where the excess of section was .12 inch or less. The non-central fractures in this case would then be accounted for by the inevitable slight variations of strength at different points in the same briquette, and they could be prevented only by taking the utmost pains in moulding.

Of the 488 briquettes broken only 89 were sand mortars. A separate comparison of these is of some interest, but the results would need to be confirmed by a greater number of tests. It is seen by Table II that, while the strength of the neat cement briquettes increased with the length between gripping points, the sand mortars showed about the same strength for all lengths, so that in their case the excess of strength at different sections would be about the same as the excess of section over 1 square inch. From this greater excess of strength, as compared with neat cement briquettes, we would expect the sand mortars to be less likely to break non-centrally than the neat cement, and this is the case. Of the eighty-nine sand briquettes only five broke outside the 5 per cent. limit of area excess over 1 square inch, and of these five the greatest excess of section at point of fracture was 6.8 per cent. This discussion is only given as a suggestion. It would account for the non-central fractures corresponding to the strongest briquettes.

VI. REMARKS.

Let us now refer briefly to the conditions which should be considered in connection with standard methods of testing cement in tension, as far as moulds and clips are concerned.

1. The strength varies with the form of briquette. There are two general forms, the notched form represented by the German standard and the form with gradually sloping sides represented by A, B and D. In the former the fracture is invariably within the notch, but there is also a reduction of strength of about 13 per cent. as compared with the latter. I do not see any advantage in securing a center fracture by a notch. As the form with-

out a notch appears to be more sensitive to unfavorable conditions, it seems to me to be the more desirable of the two. There is no special value in always securing a center fracture. The ideal briquette in this respect would be one which would break centrally if it was carefully moulded and properly tested, but which would be likely to break out of center if this work was not properly done.

2. We have seen that the strength, at least for neat cement, varies to a marked degree with the length between gripping points. This length should then be fixed, and, for convenience, should be comparatively short.

3. The strength and general behavior of the briquette when tested varies with the kind of bearing points. Mr. L. C. Sabin (see *Municipal Engineering*, 1896-97) found that with rubber cushions interposed between the clips and briquette the strength was reduced 10 or 15 per cent. He found that using the Riehlé clips without rubber, with a width of specimen at gripping points of $1\frac{1}{4}$ inches, about 30 or 40 per cent of the specimens broke at the gripping points. With substantially the same distance between gripping points, 1.26 inches, I obtained only two clip breaks altogether. With a greater width at gripping points Mr. Sabin still obtained a few clip breaks, while I obtained none under similar conditions. We must conclude that the bearing points affect the results. The rubber bearings are objectionable from the destructive character of the material. If they secure center fractures invariably, accompanied by a reduction of strength, the notched form accomplishes the same result without the use of rubber. Then, again, center fractures in themselves are of little consequence unless they serve to indicate that the work of moulding and testing has been properly done. Cement clips should be simple in construction, with as few joints to get out of order as possible. For this reason sliding or pivoted points should be ruled out, unless they give better results than the solid bearing. To be brief, it is my opinion that solid, hard metal gripping points, properly rounded in both directions so as to touch at the middle of the thickness of the briquette, are the most desirable. In any case, standard bearing points should be settled upon both as to material and curvature.

4. The other point to consider in this connection is the means for adjusting the briquette in position in the clips. Every one will agree that the pull should be central,—i.e., along the axis of the briquette. In the ordinary clips we hang the specimen from the upper clip, hang the lower clip on the specimen and depend on our sight and touch to get all three in proper relative position.

The desirable thing is to have the two clips held mechanically in proper relative position, so that when the briquette is inserted and brought to a bearing the axis of the briquette will coincide with the line joining the pivots and the face of the briquette be parallel to the faces of the two clips.

A second consideration is that the four bearing points must lie in the same plane with the pivots, otherwise a bending action will occur, the clips swinging or tending to swing about the bearing points. This action is liable to occur if the clips touch over the whole width of the briquette, and can best be provided against by rounding the points in both directions.

The desirable conditions in this direction are, therefore, that the clips should be held in proper relative position so that when the briquette is inserted and brought to a bearing the axis of the briquette will coincide with the line joining the pivots, and the four gripping points will each touch the briquette in the middle of its thickness. Under these conditions the pull will be central and remain so, and no bending action will occur.

The clips designed at the Institute of Technology to secure these conditions have been described in a previous paper (see *JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES*, June, 1888). They have been in use ever since, and have given satisfaction. They could, doubtless, be improved in details. It is a question in my mind as to whether conical pivots would not be better than double knife edges. They would be simpler and answer the same purpose, if properly made of hardened steel. The special feature of the design, the side guides, have served their purpose fully.

From this discussion, then, it seems that in order to secure comparable results (this being the object of standard methods of testing cement in tension) it is necessary to fix the form of briquette, the length between gripping points and the form of the gripping points. It would also appear to be desirable for the committee to investigate the subject of mechanical means for securing the proper placing of the briquette in the clips.

POWER AND EQUIPMENT OF ELECTRIC RAILWAYS.

BY H. H. HUNT AND C. K. STEARNS, ELECTRICAL AND MECHANICAL ENGINEERS.

[Read before the Boston Society of Civil Engineers, December 21, 1898.*]

WE presume there is no doubt in the mind of any one that the electric car is an ingenious contrivance, and that its utility is demonstrated in our streets by the transportation each day of over 50 per cent. of the entire population; for it is a matter of record that, in the territory contained within a circle whose center is the Government Building in Boston, and whose radius is 15 miles in length, the average person rides nearly 200 times per annum. Doubtless those who live within three miles of the Government Building ride more frequently than 200 times per year, and those who live beyond the three-mile limit ride less frequently; but the reports show that if the contributions were made by all alike in this circular territory it would be necessary for each man, woman and child of us to turn in the considerable sum of \$10 every twelve months in order to make up the sum total of the gross receipts of our street railways; a part of one of the most remarkable industries of this century,—remarkable for its wonderfully rapid growth and development, which has resulted in an efficient system for public transportation,—a system whose details have been worked out with much care and whose achievements are admirable as they are satisfactory.

The paper which we have prepared has to do with the modern street railroad and its appurtenances; but, at the risk of “threshing old straw,” we will ask your attention to a brief recital of the principal events which mark the progress of the application of electricity to the propulsion of street cars.

While it is not at all certain who first caused a vehicle, of whatever sort, to be propelled by the electric current, we are told that as early as 1834—only a few years after Faraday’s discovery of the fundamental principle of electro-magnetic rotation—a veritable electric railroad was constructed by one Thomas Davenport, a humble Vermont blacksmith, whose brain, possessing the proverbial Yankee ingenuity, had conceived a way of propelling a car by means of the electric motor almost as soon as it was known that there *was* an electrical contrivance by which rotation could be produced. Although Davenport devised an electric railroad in every sense of the word, it was only a model, and we may, with reason, safely assume it was a crude one at that. There were no

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immediately practical results from Davenport's experiments, which are now remembered simply as interesting events in scientific history.

For the next twenty years or thereabouts experiments were conducted by many ingenious men, both in America and in Europe. But the most important work of this period was accomplished by Dr. Page, of Salem, Mass., who conducted some experiments on a comparatively large scale on the line of the Baltimore and Ohio Railroad, between the city of Washington and a small Maryland town called Bladensburg, just outside the city limits.

Dr. Page hauled a passenger coach over this line by means of an electric motor car; and the report states that he attained a speed of 19 miles per hour. This happened on April 29, 1851, "a day of great historic interest," as one writer puts it.

This experiment, like all others of that period, was a failure from a commercial standpoint; because at that time the only known method of producing the electric current was by means of the primary battery, in principle similar to the batteries which we use to ring our doorbells; and it was a very simple matter to arrive at the conclusion that the elements of the primary battery were altogether too costly a grade of fuel for the transportation of the public.

This first twenty years' experimental work with the primary battery as a source of energy resulted in the production of a miscellaneous lot of electric toys, and it marks the first epoch in the development of the electric railroad. This period would have been of very little more than historic interest had it not been for one thing, which proved later to be of great importance. During this time almost every conceivable method of conducting the battery current to the motor on the car had been utilized, including the third-rail system, the overhead trolley system and the storage battery car system, with the result that when the practical source of electric energy was devised and perfected so that the practical electric railroad was made possible no one was able to patent the application in terms broad enough to prevent others from working on the problem. In other words, the fundamental ideas were common property, and inventors were free to improve and develop these fundamental ideas unhampered by the patent rights of any one syndicate or corporation. This fact undoubtedly accounts in a large measure for the lightning rapidity with which the art of electric traction advanced after it had passed the theoretical stage of its development.

From 1851 to 1873 no important experiments directly con-

nected with the electric railway are reported, but during this time the dynamo, as a source of electric energy, was being improved and perfected, thereby laying the foundation for the solution of the railroad problem by placing before the world a practical method for the production of electrical energy for power purposes on a commercial basis.

The only thing which remained to be accomplished to set the wheels of progress spinning was the discovery of the reversibility of the dynamo, whereby a dynamo-electric machine would revolve as a motor when supplied with electric energy developed by another dynamo-electric machine driven by some prime mover. In the light of our present knowledge it would seem incredible that this simple fact should lie hidden for so many years, especially as it was known that the dynamo-electric machine when supplied with the current from a primary battery would revolve as a motor. It is also a singular fact, and one not particularly creditable to the scientific world, that, in spite of the alleged fact that the reversibility of the dynamo was known in 1850, the real, practical demonstration was not made until 1873, and then simply by accident.

The account of this accidental discovery at the Vienna exposition is well known, and we will not take the time to rehearse it. It will suffice to say that the discovery was of the greatest importance, as it marked the beginning of the period which covers practically all the development of the propulsion of street cars by electricity.

The first six years following 1873 were consumed in desultory experiments which failed, for one reason or another, to amount to much, until Siemens & Halske, in 1879, built a semi-experimental line at the industrial exposition at Berlin. This line was, we believe, the first one which made a business of passenger carrying. It was about 1000 feet long, and could transport twenty passengers at a time at a speed of eight miles per hour. The road was operated on the third-rail system, and is said to have been the "practical starting-point of modern electric traction."

The success of this experiment stimulated invention both in Europe and in this country, which resulted in a commercial street railroad in Europe and several experimental lines in this country, where up to 1883 little or nothing had been done. But about this time Mr. Chas. J. Van Depoele and Mr. Leo Daft began their work, and a little later Messrs. Bentley and Knight appeared, their combined work furnishing some valuable and interesting data. Electric railroading as a business was regarded with distrust, and, while the minds of some of our brightest men were already

engaged on the problems which were rapidly presenting themselves for solution, little or no interest could be aroused among those whose capital was necessary for the substantial advancement of the art.

Next, Mr. Frank J. Sprague entered the field, first applying his efforts to the propulsion of trains by electricity on the New York Elevated Railroad system; and during the next three years he succeeded in putting in a small road at St. Joseph, Mo. This was in 1888, and it marks the end of the period during which the hardest experimental work was carried on, and during which the firm foundations were laid for the remarkable development of the next decade, for at this time the great electric companies entered the field, absorbing all that was good of the experimental work which had been done. The year 1888, which marks the beginning of the "boom" in electric traction in this country, found us with thirteen electric railroads in operation in the United States and Canada. These roads operated ninety-five motor cars over forty-eight miles of track.

The expansion of electric railroading since 1888 is forcibly illustrated by the following extracts from a recent article in the *Boston Evening Transcript*:

"The amount of capital involved in the electric street railways (in the United States alone) is about one and a half billions, and it is increasing rapidly every month. Should the National Government decide to buy all these roads it would take all the \$525,000,000 of gold, the \$120,000,000 of silver, the \$400,000,000 of certificates, the \$225,000,000 of national bank notes and \$250,000,000 of United States Treasury notes in circulation to pay for the purchase. The total population of Greater New York, Chicago, Philadelphia and Boston is not greater than the number of passengers carried by the electric cars of the nation every business day. A conservative estimate places the amount of passengers carried in a year by the electric cars at 2,660,000,000, not including the passengers transferred from one line to another. This means two rides each year for every human being on earth. The steam roads of the United States carry only 535,000,000 passengers annually over 182,000 miles of track.

"The United States companies operate 15,000 miles of electric street railways, employing over 40,000 cars in their service. . . . The payrolls of the electrical railway companies in the United States contain the names of 200,000 men."

With this historical preface we will take up the subject of the paper, "Power and Equipment of Electric Railways."

Our object is to present to you an outline of the principal problems which arise in the design and construction of electric railways, and to indicate the method of treatment. A system of electric railroad consists naturally of four parts:

1. The power station, with its prime mover and electric generators.

2. The outward distributing system or line.

3. The rolling stock, with its electrical equipment.

4. The track and return circuit.

We will take up and consider briefly each of the above topics.

POWER STATION.

The first problem to be solved in connection with the power station is its location. This is determined where the sum of the costs of power, building and real estate and distribution of power is a minimum. The cost of power depends upon the efficiency of the steam and electrical apparatus, and involves the cost of coal and its transportation and water for condensing purposes. The cost of building and real estate involves cost of land, taxes, cost of erecting building on the property foundations and the cost of the building above foundations. The cost of distribution of power depends upon the cost of the overhead conductors, which vary greatly with the location of the power station.

Inasmuch as the conditions which govern these factors are entirely independent and are governed solely by local conditions, it is apparent that the problem of location of station can only be solved by a careful and intelligent series of investigations. This point is one of great importance, and, unfortunately, one which frequently receives little or no attention. If we were presenting this paper to an assemblage of street railway men we should endeavor to impress upon their minds the necessity of intelligently solving the preliminary problems connected with street railway work, for experience has shown that much of the difficulty which is being encountered and patiently endured on many of our electric railways is due to the lack of care with which the original layout was planned.

The style of building is in a measure governed by the taste of the owner and the amount of money to be spent. Modern stations are almost universally of brick, of simple though substantial construction, with roof supported by iron trusses and suitable provision for extension of plant with the least disarrangement of existing apparatus. As in other branches of construction, engineers are continually incorporating new ideas, for convenience in operation and the reduction of operating expenses, in the form of travel-

ing cranes, coal and ash-handling apparatus, mechanical stokers, etc.; but, inasmuch as many of these devices are costly, it is a question to be decided in each special case as to how far such features may be utilized and still prove economical.

No fixed rule for the determination of the number and sizes of the units can be laid down. There are several propositions, however, which we believe are sound, and which should serve as a basis for the solution of this problem:

1. A station should have duplicate units, in order to prevent entire loss of power by the accidental shutting down of a single unit.

2. The units should be so arranged that the average daily power is generated at an economical rate.

3. Suitable provision should be made for all abnormal demands upon the station which can possibly be predicted.

4. Types and sizes of machines should be kept as uniform as possible, in order to preserve the simplicity of the plant and to avoid a multiplicity of repair parts.

Now, with these ideas in view, the logical solution of the problem would seem to be as follows:

First determine the number of cars to be operated by estimating the number of passengers which will be carried per day, also the rates at which passengers must be moved during the hours of maximum traffic, usually nights and mornings, and in some mill localities also at noon. Having determined the nature and extent of the daily work, it is safe to assume that on roads operating five or six cars, the station capacity must be about 50 H. P. per car to provide sufficient power for maximum loads. The average power consumed in the majority of cases is less than one-half this amount, and, as the number of cars operated increases, the allowance of station power per car will naturally approach more nearly to the average consumption per car as the peaks of the load will tend to diminish. The term "peaks of the load" will be explained and illustrated by Figs. 1 and 2, which are plots of the actual power readings in a small power station operating an electric railway. Fig. 1 shows readings taken every fifteen minutes during an entire day, while Fig. 2 shows fifteen second readings during forty minutes. In each case the heavy, straight, horizontal line represents the average power, and the points, showing fluctuations above the average, are what are termed "peaks of the load."

It sometimes happens that peculiar conditions arise which call for even more power than that indicated above; such, for instance, as the simultaneous occurrence on heavy grades of a number of

cars. In such cases, unless the schedules can be so arranged as to avoid this, an extra allowance of power must be provided for the maximum loads.

Having arrived, after a careful consideration of the possibilities, at a clear idea of the nature of the traffic requirements, it will usually be found that during the greater part of the day a normal average load must be carried, and that this normal average load will be exceeded by the average loads of Sundays, holidays, etc., and possibly that it may be very greatly exceeded on certain special occasions, such as ball games, horse races or events which gather together large masses of people.

With this data before us the logical arrangement of station apparatus would seem to be somewhat as follows:

First we should have a unit of sufficient size to take care of the normal average load, and a duplicate of this to allow alternate operation and ample opportunity for frequent inspection and repairs, when necessary, without being obliged to shut down the entire plant or to operate temporarily a larger unit than necessary, with consequent loss in economy. With this duplicate plant somewhat more than double the average load can be handled if necessary, and if the maximum load requires more power a third unit may be installed to provide for this maximum.

In modern stations it is frequently the case that two units are installed, one sufficient for ordinary requirements and the other, say, 50 per cent. larger than the first; the idea being to run the small unit practically all the time, and the larger one in case of emergency or of maximum load. It would seem that, by this plan, one part of the plant must necessarily do much more work than the other, and it would further seem preferable to so arrange the plant that each unit would do its equal portion of the work.

The engine should have an extra heavy fly wheel and be of sufficient size and suitable regulation to hold its speed constant to within 2 per cent. for all variations of load between friction load and 30 per cent. overload.

The question as to whether direct or belted connection should be used is a financial rather than an engineering problem in stations of ordinary size, as the difference in efficiency of direct connection over belted connection in such stations has not been found to be great. The factors which determine the feasibility of the one or the other are: The decrease in floor space, and consequent decrease in cost of building, and the abolition of cost of belting compared with the additional cost of direct-connected machinery over belted.

In almost every case it will be found that the direct-connected plant will exceed the belted in cost, but will, at the same time, be slightly more efficient. A conservative estimate of the difference in efficiency is 5 per cent. in favor of direct connection, so that you have now the necessary elements for determining which form of connection shall be employed.

The best practice of to-day calls for the use of high-pressure steam, with an approved form of water tube boiler. Many plants still use the horizontal return tubular boiler on account of its simplicity and low cost, but in all the largest and best installations in this country the water tube boiler will be found. Time will not permit us to consider the various makes of water tube boilers, whose economy has been found to depend rather upon the efficiency of the fireman than upon the special design of the boilers. The question of the design and arrangement of feed water heaters and economizers must be decided for each special case. In general, only such apparatus as will admit of ease in cleaning and repairs should be selected, and, in the case of heaters, only those having straight tubes should be used when the feed water shows signs of impurity. Copper tubes should also be used. A properly designed system of feed water heaters should save 1 per cent. of coal for each 11° rise in temperature of feed water, and in a well-designed plant the feed water may readily be heated to 200° F.

Economizers show a saving of 10 to 15 per cent. in coal consumption under favorable conditions, and in large plants may frequently be utilized advantageously. In small plants we have not found economizers of advantage, because of the considerable first cost and subsequent cost of operation.

The use of forced or induced draft will often be found advantageous, especially when cheap grades of fuel must be used. Another advantage in the use of fans is the flexibility of such a system, which, especially in railway work, where additions may become necessary, is a very desirable feature. As far as first cost is concerned, the blower system will generally be less than the natural draft with brick stack. It is hardly necessary to add that, in case water can be obtained cheaply, condensers should always be used, giving an increased capacity of the plant of about 20 per cent.

One of the most important features of the steam plant is the piping system, which may be an efficient steam conveyor or a constant source of trouble and annoyance, affecting the safety and economy of the plant, accordingly as the work is properly or improperly done. In general the piping of a steam plant should be so arranged that, in conjunction with its accessories, dry steam will

be delivered to the engines, and all moisture of condensation or otherwise will be carried off by a well-arranged system of drainage. Of course, the system should be laid out to conduct the steam with as little loss in pressure as possible, and a sufficient number of valves incorporated to allow the greatest possible flexibility of the system in case of breakdown of any of the apparatus.

Another point which should receive careful attention is the size of piping. It is preferable to tend toward small rather than large pipe, and to take steam from a receiver placed in the piping system immediately before the cylinder of the engine. This arrangement steadies the flow of steam and prevents vibration of the pipe, a feature which represents loss of energy, liability of leakage and annoyance generally. The loss of heat by radiation is also reduced by the smaller pipe, and the increased friction over that developed in the larger pipe tends to dry the steam. A steam velocity of 100 feet per second has been found to give very satisfactory results on the points above mentioned. Piping should be as short and direct as possible, and extra heavy iron bends are preferable to copper bends.

As to pipe covering, tests at the Massachusetts Institute of Technology, by Professor Norton, at a temperature corresponding to 200 pounds steam pressure, show that, taking the heat radiated from a bare pipe as 100, the heat radiated from covered pipe varies from 15 to 26, according to covering used. Upon the basis of the catalogue list prices he shows that pipe covering will pay for itself in six months' time. Actual bids recently submitted for the pipe covering of an 800 kilowatt plant show that the covering will pay for itself in the saving of coal in about four months' time, so that the item of first cost does not enter materially into the question. As is frequently the case in other matters, the best is the cheapest.

Regarding the electrical apparatus, we will simply call attention to one or two specifications which should be regarded in laying out a plant. The design and capacity of the machines should be sufficient to prevent heating to more than 45° C. above the surrounding atmosphere of any part of the machine except commutator, and 55° at commutator after ten hours' run at full load, one-half hour at 25 per cent. overload and temporary overload at 35 per cent. It is customary and desirable to so build the generators that they will generate 500 volts at no load and 550 volts at full load to help out the drop in voltage, which will presumably occur at the most distant parts of the line at time of maximum load.

The station should be supplied with an accurate recording watt-meter, for the purpose of measuring the electrical output of

the station, in addition to the regular electrical measuring instruments which are ordinarily supplied with railway switch boards. The watt-meter should be installed and maintained with great care, and calibrated sufficiently often to insure the accuracy of its records. By means of this instrument the net results of the power production at the station are recorded, without which data it is impossible to accurately determine the cost of power.

The character of the load on an electric railway power station is exceedingly fluctuating. Figs. 1 and 2 show the character of these fluctuations. It is evident from the diagrams that the electrical equipment of a railway power station must be much greater in capacity than the average requirements,—*i.e.*, on account of the

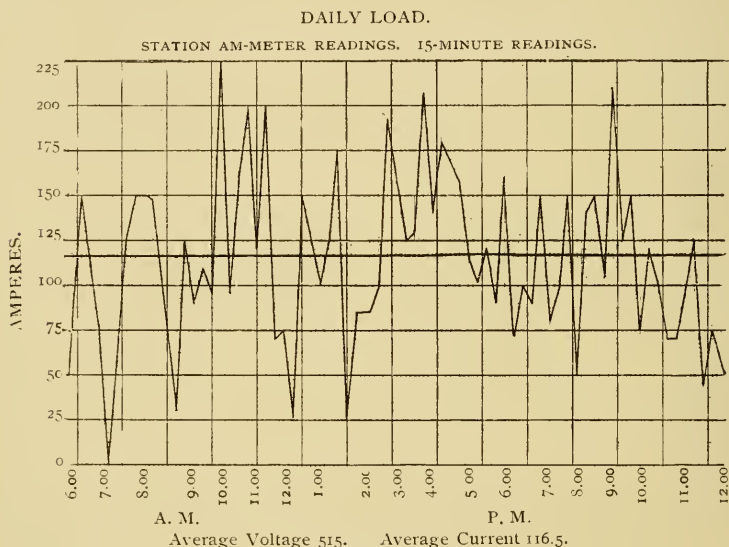
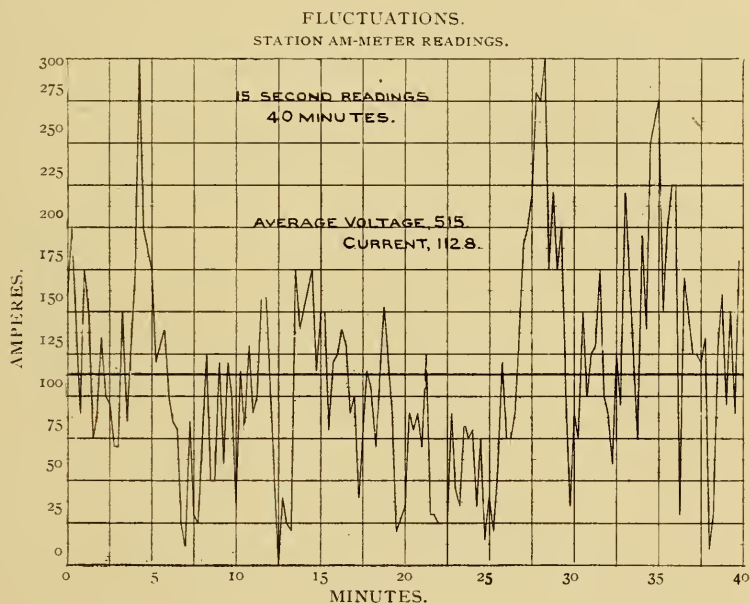


FIG. 1.

fluctuations, a considerable proportion of the plant must be held in reserve to take care of the peaks of the load. It is plain, therefore, that any device which will store up energy during the time when the load is below the average, and give out the stored energy when the load is above the average, will allow the use of a smaller plant which will be operated under a steady load and at a consequently greater efficiency.

The secondary or storage battery has been used in connection with the ordinary electrical equipment for this purpose, and has served its purpose well. When the plant is originally laid out for the storage battery as an auxiliary a considerable saving in first cost of steam plant can be effected, and consequently a saving in

coal consumption in the manner above described. For plants already built, and not originally designed for the storage battery as an auxiliary, a considerable increase of station capacity may be secured by the addition of a storage battery without the necessity of increasing the steam plant, thereby making it possible to handle an average load equal to the full capacity of the steam plant; the battery taking the peaks of the load. The use of the storage battery for this purpose is one of the later improvements in station practice, and the reports of plants already in operation indicate that the plan is a success.



OVERHEAD LINE.

The distribution of copper in the overhead distributing system is the most important problem connected with the overhead line. On account of the continual shifting of the load from one part of the line to the other, the ordinary rules for the calculation of copper cannot be applied without modifications and approximations, which judgment alone, aided by experience, can furnish. The requirements of a properly designed system of overhead conductors are that, under all conditions of load, the working pressure of the electric energy shall be maintained within certain limits of safety to the apparatus at every part of the line. A little reflection as to the significance of this statement on lines containing heavy

grades, curves and irregular schedules, etc., will reveal the difficulties of the problem.

In practice it has been found that a road of about ten miles can be satisfactorily operated from one station without an exorbitant outlay in copper. Some roads somewhat longer than ten miles are fed from a single station, but we have frequently found that on such roads, where the attempt is made to transmit power by the ordinary direct-current method at 500 to 550 volts, the amount of copper necessary to do the work is so great that the copper is never erected, and continual trouble is experienced in the form of burned-out motors and slow speed. There are several methods available for operating long lines, such as by increasing the number of power stations and dividing the line into two or more short lines, as the case may require, or the transmission of power at higher voltage than that employed at the car motors.

Anything like a detailed explanation of the various methods of long distance power transmission would require much more space than can be allotted here, as it is a most complex subject. It may be said in general, however, that it is possible to transmit power over about ten miles of road in a very satisfactory manner at 550 volts, and from a single station; and that several ways have been devised whereby this distance may be increased to almost any practical extent; a combination of the two methods above mentioned will afford power transmission for any distance.

The balance of the problems connected with the construction of the overhead line are largely mechanical, and a description of the minutiae connected with the proper erection of an overhead line would take some time and be little more than a rehearsal of a multitude of details of no special interest to those not directly connected with the construction business. The line should, of course, be suspended in a neat and sufficiently substantial manner to sustain the severe usage to which it will be subjected. One other point of importance is the protection of the line from lightning. Approved forms of lightning arresters should be erected at least every half mile, and these arresters should be carefully installed and maintained. Efficient protection from lightning may save hundreds of dollars damage to the electrical plant, for lightning plays sad havoc with electrical machinery if allowed to enter the station unimpeded.

TRACK AND RETURN CIRCUIT.

The principal mechanical requirements for the track are that it shall be substantially built and carefully maintained. Rough

track, besides being decidedly uncomfortable for the passengers, racks the cars and motors, consumes power and increases the danger from derailment.

The principal electrical problem in connection with the track is the problem of rail bonding,—*i.e.*, the bridging of the rail joints by metallic conductors or bonds so as to provide an uninterrupted path for the return of the current from the cars to the station. No problem connected with the electric railway has occasioned more thought than has rail bonding, and no feature of the electric railroad has proved more troublesome. Defective rail bonds cause all sorts of difficulty. They not only consume power, but frequently interrupt the power entirely. They impose abnormal electrical strains upon the motors, ultimately causing burn-outs and heavy repair bills. Another extremely troublesome outcome from poor rail joints is the electrolysis of water and gas pipes.

Popularly speaking, it is a well-known fact that the electric current always traverses the path of lowest resistance,—the shortest electrical path. A more accurate way of stating this fact would be as follows: If several paths of varying electrical resistance connect two points which are subjected to a difference of electrical pressures or potentials, electric currents (so-called) will flow in each of these paths, and the amount of current in each path will be proportional to the conductivity of the path. This principle is applicable to track circuits, for if there are poor rail joints of great electrical resistance, and there are other continuous masses of metal adjacent to the track whose electrical resistance is less than that of the track, the current will divide itself into parts proportional to the conductivity of the respective paths. Water pipes and gas pipes form very convenient adjacent paths, and practice furnishes many instances where underground pipes have conducted large amounts of electrical energy which should have been conducted in other ways. No injury to the pipe will result from the current in passing to the pipe or as long as it remains on the pipe, but when the current goes from pipe to earth, as it must eventually do in order to reach the power station from whence it came, the trouble occurs. At each point where the current leaves the pipe and goes into the earth corrosive action is set up, which results in the gradual destruction of the iron at this point. This action is called electrolysis, and has proved disastrous to water and gas pipes in some places.

The remedies for this are two: First and best is prevention by proper rail bonds, thereby preventing the greater part of the current from leaving the track. Second, by carefully connecting

the gas and water pipes to the station by means of conductors, thereby preventing the current from passing from the pipe to the earth.

It goes without saying that numberless styles and kinds of rail bonds have been devised. The problem is not an easy one, for the

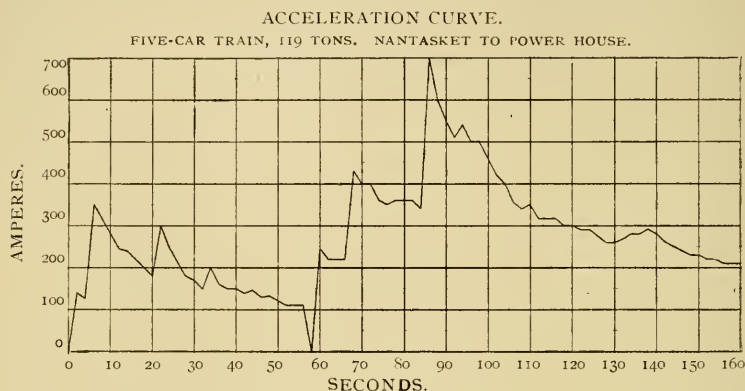


FIG. 3.

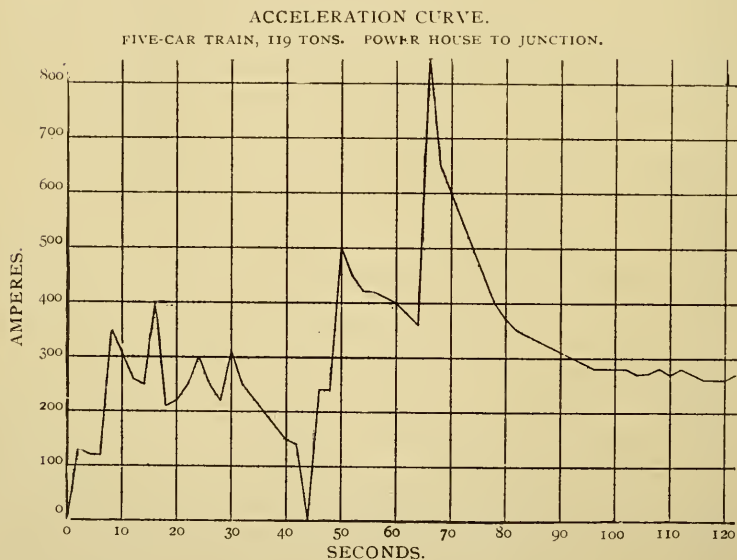


FIG. 4.

bond is in most cases underground, where it is subjected to the action of moisture and the wrenching due to the movement of the joints by the passing cars. It is generally sufficient to bridge each rail joint by two short flexible copper bonds not less than No. 0000 (B. & S.) gauge (.46-inch diameter), the bearing surface between

rail and bond being at least twice the area of the wire. Tinned wire should be used to prevent corrosion, and the rails should be tied together or cross-bonded at every other pair of rail joints. In applying the bonds the holes in the rail should be carefully reamed out and cleaned, and a perfectly tight and solid joint made.

CURVES OF SPEED, TORQUE AND EFFICIENCY.

G. E. 2000-RAILWAY MOTOR.

MILES PER HOUR.

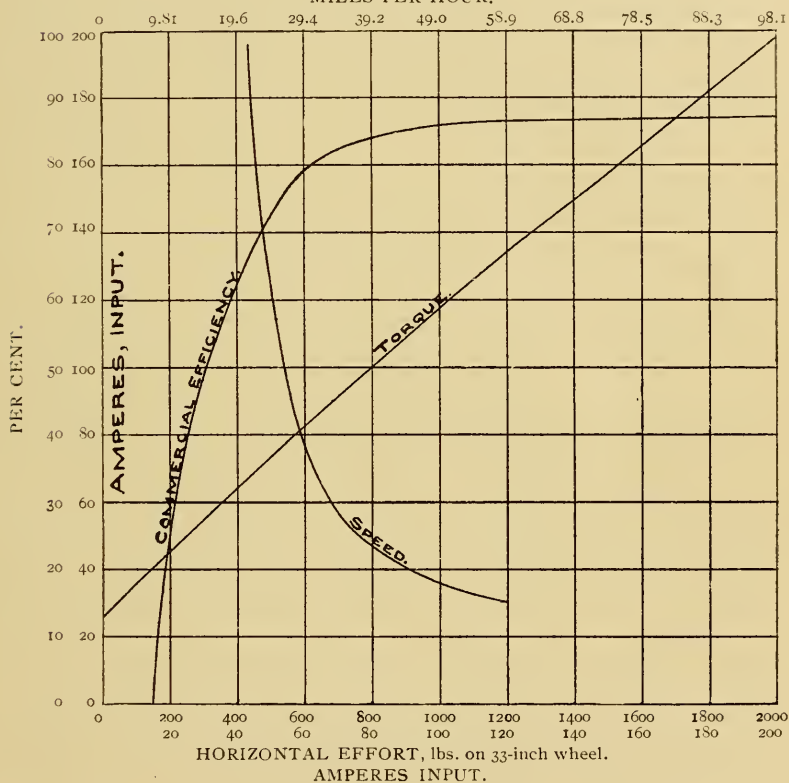


FIG. 5.

ROLLING STOCK.

The only problem which we shall mention in connection with the rolling stock is the determination of the size of motor for a given case. In practice it is generally found that the maximum tractive effort is required during the acceleration of the car, and especially is this the case on elevated railways. Figs. 3 and 4 show the consumption of power during the acceleration of a five-car train, weighing 119 tons, propelled by electricity. Starting from zero, the current increases sharply, then falls to zero, then

rises to maximum and then gradually falls to a constant value. The irregularities in the curve while rising from zero to maximum are largely due to the particular form of car controller which was used on this train. The particular point of interest is the maximum to which the current rises as the acceleration of the car increases, and then the gradual diminution of the current to a constant value as the car continues at its constant speed. While a rapid acceleration is desirable, on account of the efficiency in watt hours per ton mile, it will require a greater maximum tractive effort to obtain this acceleration, and consequently larger motors and also a greater reserve at the station to take care of the increased fluctuations.

It is obviously impossible to take actual measurements of current consumption during acceleration on a road not yet built, but the estimated maximum draw-bar pull may be readily calculated when the weight of the train and the time of acceleration have been settled upon. Having obtained the maximum draw-bar pull, it is necessary to consider it in connection with the so-called torque curves of various motors in order to select the motor adapted to the case in hand. Fig. 5 shows one of these torque curves. Starting with the horizontal effort in pounds, follow the ordinate to its intersection with the torque curve; next follow the horizontal to its intersection with the speed curve; next follow the ordinate from the point of intersection to the scales of miles per hour, which will decide whether this particular motor is adapted for the requirements. The plot also shows the commercial efficiency of the motor at various loads and the current consumption at the various speeds and torques. Motors in use may be estimated at an average running efficiency of 60 per cent. In order, then, to fix the size of the motor it is necessary to know the load to be carried, the speed required, the time in which to develop that speed and the grades to be mounted. The motor should be of sufficient capacity to fulfill these requirements without undue heating.

It is common practice to specify the heating limit as follows: After an hour's run at rated load no part of a railway motor should rise in temperature over 75° C. above the temperature of the surrounding atmosphere.

The foregoing are some of the problems which arise in electric railway practice. If we have succeeded in presenting to you a general idea of their significance and an outline of the methods by which they may be solved, we shall feel that we have, in part, at least, succeeded in our undertaking.

DISCUSSION.

MR. ALTON D. ADAMS.—It seems timely, in connection with the paper just read, to call more particular attention to the destructive action of electrolysis. The damage in the aggregate from this action is enormous, and in value many times the cost of construction necessary to prevent it.

Uncertainty as to the points at which a water or other pipe system will be attacked in any given case adds to the dangers, and the fact that pipes in some localities suffer but little damage is no guarantee in others. The only security, so long as the single trolley system is used, lies in much greater weight of copper ground returns, so as to lower the electric pressure of the entire ground return system.

DOUBLE-TRACK ELECTRIC RAILWAY FROM BUTTE TO CENTERVILLE, MONTANA.

BY FRANCIS W. BLACKFORD, MEMBER OF THE MONTANA SOCIETY OF ENGINEERS.

[Read before the Society, December 10, 1898.*]

THE city of Butte and the town of Centerville, one of its suburbs, were connected, in the year 1897, by a cable passenger railway, which did service until about a year ago, when plans were made to substitute therefor electric traction and to make the necessary changes in the alignment and grades.

The cable was run in an almost direct line between the two places. It overcame an elevation of 390 feet between Park street, Butte, and Center street, Centerville, a distance of 0.9 mile, and had grades as steep as 14 per cent.

The plan of the new enterprise was to construct a double-track electric railway, if possible, upon grades not exceeding 5 per cent., and located so as to accommodate the greatest number of people residing in the several settlements lying between the two places.

In pursuance of this plan a number of lines were run in the summer of 1897 by Mr. W. H. Harrison, C. E., under the general direction of the writer, and the possibilities were pretty well understood before the final location was begun. In these preliminary location lines complete circles, of radii to suit the conditions, were used in development, and many interesting engineering features were introduced to overcome the elevation and avoid expensive or objectionable places. It was, however, found to be impracticable to adhere to a grade of 5 per cent., and in the final location grades of 6 and $7\frac{1}{2}$ per cent. were introduced in places, with rates varying from level up to these, as shown by the profile, Fig. 2.

As the location progressed it was found that the right of way was the paramount question, and of greater importance than the physical difficulties to be overcome. While farm and town or city property has a pretty well-established value, easily determined by testimony before a commission, the determination of the value of a piece of undeveloped mining property is a very different and a very difficult matter. The owner of such property can often prove the value of his surface ground, for use in the development of the mine, to be so great in a single instance as to practically kill such an enterprise; and the only thing to do in such cases is to avoid the property, or at least that part of it which is likely to be used for developing the mine.

*Manuscript received December 28, 1898.—Secretary, Ass'n of Eng. Socs.

The company's charter gave power to condemn land for a right of way, but, for the reasons above stated, it was thought best to locate the line upon ground which could be purchased at reasonable prices; and the location was so made, the right of way therefore becoming one of the controlling features of the location.

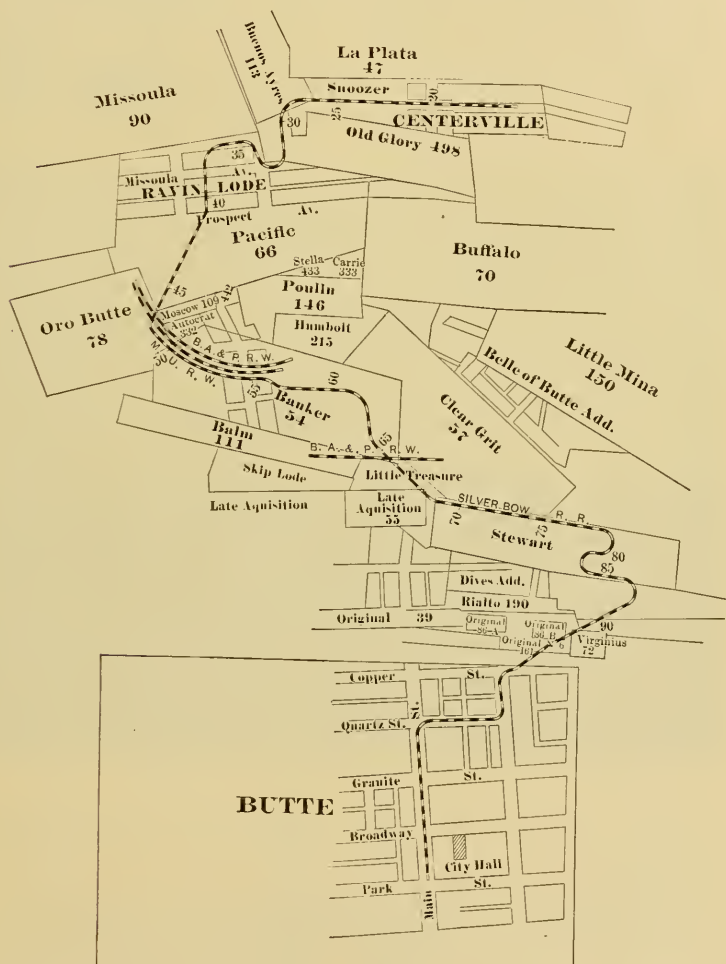


FIG. 1. SILVER BOW RAILROAD FROM BUTTE TO CENTERVILLE, MONTANA.

The crossings of the three steam railroads were made overhead upon steel spans or plate girders, the other crossings, four in number, were wooden bent trestles. While the latter contain no unusual features, the plans were prepared especially for this work. They were planned to carry "Jumbo" cars of 15 tons weight, with a load of 180 persons, or a total weight of 30 tons. The elevation

of the track on curves was computed for a speed of 12 miles per hour, and on the bridges was obtained by means of a false cap.

The curves vary in radius from 64 to 143 feet, with transition curves at the ends increasing 10° every 10 feet upon the lighter curves and 10° every 5 feet upon the heavier ones.

No compensation of grade on curves was made because the power supplied to the cars was ample to enable them to ascend much steeper grades, the objection to the heavy grades being the difficulty in safely descending them. Upon this line, which overcomes an elevation of 416 feet, and has $1\frac{3}{4}$ miles of almost con-



FIG. 3. DEVELOPMENT, WITH 5% GRADE, NEAR STATION 80.

tinuous grade, the safe descent is the special feature of its operation.

Except on the paved streets of Butte, the road is laid throughout with 52-pound second-hand steel rail that had been in use on the Oregon Short Line Railway. The rail was but little worn, and it makes an excellent track.

The rails are bonded with the Atkinson horseshoe bond, N 0000, cross-bonded every 600 feet.

The power is transmitted by the usual overhead wire, supported by cedar poles on each side. The feed wire, however, does not follow the meanderings of the road, but runs straight up the hill and feeds at the crossings and at the end of the line.

The line is equipped with 16-foot single-truck cars, with 30-inch wheels and two 35-horse power General Electric No. 1000 motors on each car.

In addition to the usual chain brake, the cars have the General Electric electric brake, the latter being used as an emergency brake only. They also have the General Electric K-10 controller.

The trip from the corner of Park and Main streets, Butte, to the corner of Center and Main streets, Centerville, a distance of $1\frac{3}{4}$ miles, is made with ease in fifteen minutes, each car making two round trips per hour.

The line has been in successful operation since August 7, 1898, and no accidents or runaways have occurred. In only one instance has the emergency brake been applied.

ASSOCIATION OF ENGINEERING SOCIETIES.

Articles of Association.

The following Articles of Association were adopted at a meeting held in Chicago, December 4, 1880. At this meeting there were present representatives of the

Western Society of Engineers,
Civil Engineers' Club of Cleveland,
Engineers' Club of St. Louis,
and the
Boston Society of Civil Engineers
was represented by letter.

FOR THE PURPOSE OF SECURING THE BENEFITS OF CLOSER UNION AND THE ADVANCEMENT OF MUTUAL INTERESTS, THE ENGINEERING SOCIETIES AND CLUBS HEREUNTO SUBSCRIBING, HAVE AGREED TO THE FOLLOWING

ARTICLES OF ASSOCIATION.

ARTICLE I.

NAME AND OBJECT.

The name of this Association shall be "THE ASSOCIATION OF ENGINEERING SOCIETIES." Its primary object shall be to secure a joint publication of the papers and the transactions of the participating Societies.

ARTICLE II.

ORGANIZATION.

SECTION 1. The affairs of the Association shall be conducted by a Board of Managers under such rules and by-laws as they may determine, subject to the specific conditions of these articles. The Board shall consist of one representative from each Society of one hundred members or less, with one additional representative for each additional one hundred members, or fraction thereof over fifty. The members of the Board shall be appointed as each Society shall decide, and shall hold office until their successors are chosen.

SEC. 2. The officers of the Board shall be a Chairman and Secretary, the latter of whom may or may not be himself a member of the Board.

ARTICLE III.

DUTIES OF OFFICERS.

SECTION 1. The Chairman, in addition to his ordinary duties, shall countersign all bills and vouchers before payment and present an annual report of the transactions of the Board; which report, together with a synopsis of the other general transactions of the Board of interest to members, shall be published in the Journal of the Association.

SEC. 2. The Secretary shall be the active business agent of the Board and shall be appointed and removed at its pleasure. He shall receive a compensation for his services to be fixed from time to time by a two-thirds

vote. He shall receive and take care of all manuscript copy and prepare it for the press, and attend to the forwarding of proof sheets and the proper printing and mailing of the publications. He shall have power, with the approval of any one member of the Board, to return manuscript to the author for correction if in bad condition, illegible, or otherwise conspicuously deficient or unfit for publication. He shall certify to the correctness of all bills before transmitting them to the Chairman for counter-signature. He shall receive all fees and moneys paid to the Association and hold the same under such rules as the Board shall prescribe.

ARTICLE IV.

PUBLICATIONS.

SECTION 1. Each Society shall decide for itself what papers and transactions of its own it desires to have published and shall forward the same to the Secretary.

SEC. 2. Each Society shall notify the Secretary of the minimum number of copies of the joint publications which it desires to receive, and shall furnish a mailing-list for the same from time to time. Copies ordered by any Society may be used as it shall see fit. Payments by each Society shall in general be in proportion to the number of copies ordered, subject to such modification of the same as the Board of Managers may decide, by a two-thirds vote, to be more equitable. Assessments shall be quarterly in advance, or otherwise, as directed by the Board.

SEC. 3. The publications of the Association shall be open to public subscription and sale, and advertisements of an appropriate character shall be received, under regulations to be fixed by the Board.

SEC. 4. The Board shall have authority to print with the joint publications such abstracts and translations from scientific and professional journals and society transactions, as may be deemed of general interest and value.

ARTICLE V.

CONDITIONS OF PARTICIPATION.

SECTION 1. Any Society of Engineers may become a member of this Association by a majority vote of the Board of Managers, upon payment to the Secretary of an entrance fee of fifty cents for each active member, and certifying that these Articles of Association have been duly accepted by it. Other technical organizations may be admitted by a two-thirds vote of the Board, and payment and subscription as above.

SEC. 2. Any Society may withdraw from this Association at the end of any fiscal year by giving three months' notice of such intention, and shall then be entitled to its fair proportion of any surplus in the treasury, or be responsible for its fair proportion of any deficit.

SEC. 3. Any Society may, at the pleasure of the Board, be excluded from this Association for non-payment of dues after thirty days' notice from the Secretary that such payment is due.

ARTICLE VI.

AMENDMENTS.

These articles may be amended by a majority vote of the Board of Managers, and subsequent approval by two-thirds of the participating Societies.

ARTICLE VII.

TIME OF GOING INTO EFFECT.

These articles shall go into effect whenever they shall have been ratified by three Societies, and members of the Board of Managers appointed. The Board shall then proceed to organize, and the entrance fee of fifty cents per member shall then become payable.

These articles were adopted by the several Societies upon the following dates:

- Engineers' Club of St. Louis, January 5, 1881.
- Civil Engineers' Club of Cleveland, January 8, 1881.
- Boston Society of Civil Engineers, January 19, 1881.
- Western Society of Engineers, April 5, 1881.

The Board of Managers was organized at Cleveland, January 11, 1881.

The following Societies have since certified their acceptance of the articles, and have become members of the Association of Engineering Societies:

- Engineers' Club of Minneapolis, July, 1884.
- Civil Engineers' Society of St. Paul, December, 1884.
- Engineers' Club of Kansas City, January, 1887.
- Montana Society of Civil Engineers, April, 1888.
- Wisconsin Polytechnic Society, June, 1892.
- Denver Society of Civil Engineers, January 24, 1895.
- Association of Engineers of Virginia, February 1, 1895.
- Technical Society of the Pacific Coast, March 1, 1895.
- Detroit Engineering Society, January, 1897.
- Engineers' Society of Western New York, January, 1898.
- Louisiana Engineering Society, September 15, 1898.

The Wisconsin Polytechnic Society withdrew from the Association in March, 1894.

The Western Society of Engineers withdrew in December, 1895.

The Engineers' Club of Kansas City disbanded at the close of 1896.

The Denver Society of Civil Engineers and the Association of Engineers of Virginia disbanded in 1898.

Annual Report of the Chairman of the Board of Managers.

DECEMBER 31, 1898.

To the Members of the Board of Managers of the Association of Engineering Societies:

GENTLEMEN:—Your Chairman has the honor to present to the Association through you the annual report of your transactions during the year 1898.

The publication of the JOURNAL, the principal business of the Board, has been managed largely by your efficient Secretary, whose faithful and valuable services should be again acknowledged, and whose lucid report is herewith transmitted. The JOURNAL has appeared with regularity and with reasonable promptness, its general make-up and appearance being in keeping with the excellent character of the papers which have been published during the year. The report of the Secretary shows a gratifying increase in the number of pages of the JOURNAL, although the number of articles

remains but 45, as last year. The attention of the local societies is again called to the desirability of publishing a larger number of papers, thus increasing the value of the JOURNAL as well as extending the advantages of the meetings of the Societies.

The excellent financial condition of the Association, allowing a considerable reduction of annual dues during the year with prospects for further reduction, as exhibited in the detailed report of the Secretary, is a matter for congratulation.

As noted by the Secretary, we have had the pleasure of receiving into our Association three new Societies whose aggregate membership of 204 far more than balances numerically that of the two Societies which have practically gone out of existence. This material growth is also a cause for congratulation.

Aside from the changes in membership and the routine details connected with the publication of the JOURNAL, attention may be called to the following as the more important actions taken by the Board:

A new rule has been adopted regarding advertisements secured for the JOURNAL, the Secretary's remarks concerning which are commended to the careful consideration of the Societies.

The Board voted 9 yeas to 5 nays to allow authors of papers published in the JOURNAL to append to their names, in addition to "Member of —— Society," such college degrees and scientific society memberships as they may choose, also a statement of their present or past professional position. Experience up to the present time indicates no tendency to abuse the privilege thus extended, and it is expected that no abuse will arise.

The proposition to hold the Secretaries of local Societies responsible for the accuracy of such statements was voted down, as was also the proposition to have the Secretary prepare brief sketches of authors of papers in the JOURNAL.

In order to facilitate the transaction of business the proposition was made to have all ballots close six weeks after the date of mailing blanks to the members of the Board of Managers. Sixteen votes were received, all in the affirmative.

A suggestion from the Engineers' Club of St. Louis that a directory of the members of the Societies in the Association should be prepared and printed in the JOURNAL has been under consideration. Some members of the Board objected to having it printed as part of the JOURNAL, preferring to have it appear as a separate pamphlet to avoid any appearance of padding.

A compromise has been adopted and the list of names and addresses will be included in the proceedings of the current number. If this meets the approval of the Societies an effort will be made to have a complete directory prepared for next year, which shall give not only the names and addresses but also the professional positions occupied by the members. It is hoped that this feature will strengthen the bond of community among the constituent Societies.

As the value of the JOURNAL and of the Association is commensurate with the membership, I desire to raise a question with regard to the desirability of inviting the co-operation of the Clubs of mechanical, electrical and other engineers in several of the larger cities. At present the Association consists of several civil engineering Societies and of others whose names

indicate a wider range of membership. As the articles of Association contain nothing to indicate that the membership was designed to be limited to civil engineers, and as most if not all of the Societies now in the Association include other than civil engineers, I desire to learn the sentiments of the members regarding the desirability of increasing our numbers by encouraging the co-operation of such other engineering Clubs as have professional standing.

In closing I desire to thank the Board for the honor and confidence shown me, to acknowledge the hearty co-operation of the Secretary and to express the hope that during the ensuing year the Association may grow yet stronger and better.

Respectfully submitted,

GEO. D. SHEPARDSON, *Chairman.*

Annual Report of the Secretary of the Board of Managers.

PHILADELPHIA, December 31, 1898.

Prof. George D. Shepardson, Chairman,

University of Minnesota, Minneapolis, Minn.

DEAR SIR:—I have the honor to present the following report upon the operations of the Secretary's office during the year 1898, and of the condition of the Association at the present time.

These data are concisely stated in the following statistical appendices:

A. Statement of receipts and expenditures during 1898.

B. Estimate of assets and liabilities at the close of 1898.

C. Detailed statement of cost of JOURNAL during 1898.

D. Comparison of mailing lists of the JOURNAL, at the close of 1897 and of 1898, respectively.

E. Statement of material in JOURNAL during 1898, by pages.

F. Comparison between operations and conditions during 1897 and 1898.

A comparison of these appendices, and particularly of Appendix F, shows a most gratifying condition of the affairs of the Association, even when compared with the exceptionally favorable year of 1897.

Notwithstanding a further reduction of the annual assessment from \$2.50 to \$2.00 per member, the cash balance at the end of the year shows an increase over that at the end of 1897, and the excess of assets over liabilities shows a still greater increase.

A further reduction in assessments will certainly be in order in 1899.

The assets and liabilities and annual assessments during several recent years have compared as follows:

	Annual Assessment per Member.	Excess of Liabilities over Assets.	Excess of Assets over Liabilities.
1894	\$3.00.....	\$758.91	
1895	3.66.....		\$223.93
1896	3.00.....		1,244.94
1897	2.50.....		2,562.04
1898	2.00.....		2,936.71

I still await favorable action by the Societies in the matter of procuring from their members advertisements for the JOURNAL of the Association. In the hope of stimulating such action, the Board of Managers, during 1898,

increased, from 50 to 90 per cent., the discount allowed to Societies for such advertisements, but thus far this measure has borne no fruit.

This is greatly to be regretted, not only on account of the Societies themselves, but also on account of the Association, for its efforts to secure the co-operation of Societies still outstanding would be very greatly strengthened if it could be shown that some, at least, of our Societies secured the advantages of co-operation with the Association without actual increase of cost to themselves.

During 1897 I had the pleasure of chronicling the accession of the Detroit Engineering Society, with 97 members.

During 1898 the Engineers' Club of Western New York, with headquarters at Buffalo, and a roll of 50 members; and the Louisiana Engineering Society, with headquarters at New Orleans, and a roll of 57 members, have joined the Association; and the admission of the Engineers' Club of Cincinnati, with a membership of 97 names, has been practically consummated.

Each new Society admitted to the Association contributes not only to its financial strength but also to the value of the JOURNAL, and thus increases the inducement to outstanding Societies to become members of the Association.

Unfortunately, during the year, the Association of Engineers of Virginia, with a mailing list of 14 names, and the Denver Society of Civil Engineers, with a mailing list of 25 names, have practically become extinct.

The total mailing list of the Societies will have increased from 1252, at the end of 1897, to 1425 at the beginning of 1899.

The average cost per page of publishing the JOURNAL during 1898 was \$3.26, as against \$3.24 in 1897.

The very trifling increase in the cost per page is far more than accounted for by the large increase in the expense for illustrations during 1898.

The total number of pages in the JOURNAL during 1898 was 1062, as compared with 968 in 1897.

The number of pages published, and the average cost per page during several recent years, have been as follows:

	No. of Pages.	Average Cost per Page.
1894	1290.....	\$4.48
1895	1482.....	3.99
1896	856.....	4.59
1897	968.....	3.24
1898	1062.....	3.26

It has been thought advisable that the Association should procure the remainder of the stock of the Index of Current Technical Literature, reprinted from the JOURNAL of the Association and published in book form in 1891, covering the years 1884-1891. This stock was accordingly purchased, at a cost of \$160, and a number of copies have been bound. Copies of these indexes, amounting to about \$100, have been sold during 1898.

JOHN C. TRAUTWINE, JR., *Secretary.*

APPENDIX A.

STATEMENT OF RECEIPTS AND EXPENDITURES DURING 1898.

CASH, 1898.

Dr.

To Balance, January 1, 1898.....	\$1,995 53
“ Assessments:	
Boston Society of Civil Engineers.....	\$941 00
Civil Engineers' Club of Cleveland.....	343 50
Engineers' Club of St. Louis.....	362 00
Civil Engineers' Society of St. Paul....	49 50
Engineers' Club of Minneapolis.....	35 75
Montana Society of Engineers.....	230 50
Denver Society of Civil Engineers....	6 50
Association of Engineers of Virginia..	24 50
Detroit Engineering Society.....	190 50
Technical Society of the Pacific Coast..	270 25
Engineers' Soc'y of Western New York	100 00
Louisiana Engineering Society	33 06
	<hr/> 2,587 06
“ Initiation fees:	
Engineers' Soc'y of Western New York	25 00
Louisiana Engineering Society.....	28 50
“ Subscriptions	513 19
“ Sales of JOURNALS	186 36
“ “ “ Descriptive Index	29 50
“ Advertisements	520 83
“ Sales of Reprints.....	263 38
“ “ “ Periodicals	29 85
“ Interest on deposits	23 85
	<hr/> \$6,203 05
<i>Cr.</i>	
By Patterson & White (Printers).....	\$2,343 89
“ Illustrations	761 52
“ Secretary's salary	600 00
“ Car fares	1 70
“ Mimeographing, etc.....	17 50
“ Discounts on subscriptions.....	25 00
“ “ “ sales	4 15
“ “ “ advertisements	55 25
“ Messenger service.....	2 85
“ Stationery	10 50
“ Telegrams	6 82
“ Postage stamps	26 55
“ Express charges.....	4 66
“ Back numbers bought	8 00
“ Advertising	21 09
“ Binding JOURNALS.....	3 00
“ Indexes bought	160 00
“ Traveling expenses.....	33 90
“ Expenses, S. E. Tinkham, Ex-Chairman.....	13 80
	<hr/> 4,100 18
“ Cash balance, December 31, 1898.....	\$2,102 87

APPENDIX B.

ESTIMATE OF ASSETS AND LIABILITIES AT THE CLOSE OF 1898.

AVAILABLE ASSETS.

Cash balance, December 31, 1898.....	\$2,102 87	
Less subscriptions for 1899, paid during 1898.....	68 50	
	<hr/>	\$2,034 37
Amounts receivable from Societies (for assessments, etc.):		
Civil Engineers' Club of Cleveland....	\$44 25	
Civil Engineers' Society of St. Paul....	16 50	
Montana Society of Engineers.....	162 25	
Association of Engineers of Virginia...	3 50	
Technical Society of the Pacific Coast..	32 00	
	<hr/>	\$258 50
Subscriptions due:		
For 1898.....	276 00	
" 1897	105 00	
" 1896 and earlier.....	108 00	
	<hr/>	489 00
For reprints	133 60	
" Advertisements	217 33	
" Sales of JOURNALS.....	14 90	
" " " Index	84 40	
" Copyright fee.....	1 00	
	<hr/>	1,198 73
		<hr/>
		\$3,233 10

LIABILITIES.

Patterson & White (Printers):		
For December JOURNAL.....	\$192 30	
" Reprints	34 20	
" Letter heads, etc.....	1 75	
" Sundries	39 39	
	<hr/>	\$267 64
E. Halfenson.....	3 50	
Boston Society of Civil Engineers	1 85	
Civil Engineers' Club of St. Louis	9 50	
William Rutter Co.....	13 90	
	<hr/>	296 39
		<hr/>
Excess of assets over liabilities		\$2,936 71

APPENDIX C. Detailed Statement of Cost of JOURNAL During 1898.

1	2	3	4	5	6	7	8	9	10	11	12	13
Composition.	Paper, Presswork, Binding.	Wrapping, etc.	Postage.	Patterson & White, 1, 2, 3 and 4	Illustrations *	Cost of Manufacture, 1, 2, 6.	Wrappers.	Secy's Salary.	Supplies.†	Total.‡	No. of Pages.§	Cost per Page.
January.....	\$124 25	\$7 17	\$12 06	\$272 65	\$49 00	\$302 42	\$4 75	\$50 00	\$15 25	\$391 65	146	\$2 68
February.....	87 75	5 10	7 48	171 76	70 50	229 68	4 75	50 00	2 34	299 35	82	3 65
March.....	87 25	5 62	9 42	189 72	120 09	294 77	4 75	50 00	7 95	372 51	100	3 72
April.....	90 75	5 39	10 09	206 06	36 50	227 08	4 75	50 00	18 57	315 88	104	3 03
May.....	74 25	6 20	8 27	135 62	129 40	270 55	4 75	50 00	5 40	345 17	82	4 21
June.....	70 25	4 65	7 50	150 41	27 94	166 20	4 75	50 00	2 25	235 35	78	3 02
July.....	53 25	5 25	6 41	103 11	54 50	145 95	4 75	50 00	3 50	215 86	56	3 85
August.....	57 75	5 21	8 62	114 01	144 46	244 64	4 75	50 00	15 00	328 22	62	5 29
September.....	59 25	4 50	6 54	110 14	47 99	147 09	4 75	50 00	3 35	216 23	60	3 60
October.....	69 75	4 20	7 19	132 71	36 00	157 32	4 75	50 00	7 89	231 35	74	3 12
November.....	82 75	4 80	9 41	191 16	13 00	189 95	4 75	50 00	2 30	261 21	114	2 20
December.....	90 75	5 60	10 62	187 55	.....	171 33	4 75	50 00	7 00	249 30	104	2 40
Totals and averages...	\$948 00	\$63 69	\$103 61	\$1,984 90	\$729 38	\$2,546 98	\$57 00	\$600 00	\$90 80	\$3,462 08	1062	\$3 26

*The figures in column 6 include preparation of cuts and lithographic stones, and paper and presswork on insets.

†The figures in column 10 include all expenditures of the Association (such as stationery, postage, circulars, etc.) chargeable to the JOURNAL, and not embraced in any other column. They do not include the cost of preparing reprints of papers.

‡Sums of amounts in columns 5, 6, 8, 9, and 10.

§The figures in column 13 include 4 cover pages in each number and 16 pages in indexes to Vols. XX and XXI.

APPENDIX D.

* Comparison of the mailing lists of the JOURNAL, at the close of 1897 and of 1898, respectively:

	1897.	1898.	In-crease.	De-crease.
Boston Society of Civil Engineers	470	485	15	..
Engineers' Club of Cleveland	148	177	29	..
Engineers' Club of St. Louis	174	191	17	..
Civil Engineers' Society of St. Paul.....	36	33	..	3
Engineers' Club of Minneapolis	15	21	6	..
Montana Society of Civil Engineers	97	107	10	..
Technical Society of the Pacific Coast....	149	126	..	23
Denver Society of Civil Engineers.....	26	25	..	1
Association of Engineers of Virginia.....	40	14	..	26
Detroit Engineering Society.....	97	91	..	6
Engineers' Society of Western New York. ..	..	43	43	..
Louisiana Engineering Society .....	..	57	57	..
	1252	1370	177	59
Extra copies to Societies	80	38	..	42
Advertisers	19	19	..	..
Exchanges	102	114	..	..
Subscribers	233	246	13	..
Complimentary copies	14	10	..	4

Besides this, many copies have been sold and specimen copies sent out; and authors of papers have each received five copies of the JOURNALS containing them. Two thousand copies of each number have been printed.

APPENDIX E.

Statement of material in JOURNAL during 1898, by pages.

	Papers.	Pro-ceed-ings.	Chair-man's Report.	Adver-tise-ments.	Indexes to Vols.	Totals.	Cuts.	Plates and full-page cuts.
January	104	16	10	16		146	37	2
February.....	56	10		16		82	35	
March.....	68	16		16		100	28	4
April.....	74	14		16		104	4	1
May.....	52	14		16		82	6	14
June.....	50	4		16	8	78	8	1
July.....	36	4		16		56	3	1
August.....	44	2		16		62		13
September.....	40	4		16		60	3	4
October.....	52	6		16		74	20	1
November.....	92	6		16		114	22	1
December.....	70	8		16	8	102		
Totals..	738	104	10	192	16	1060	166	42
Covers, etc						50		
Total.....						1110		

APPENDIX F.

Comparison between operations and conditions during 1897 and 1898:

	1897.	1898.
Excess of assets over liabilities, December 31.....	\$2,562 04	\$2,936 71
Number of Societies in Association, December 31...	10	12

Number of names on mailing lists of Societies in		
Association	1,252	1,367
" " Subscribers	233	246
Annual receipts from subscribers, at \$3.00.....	\$699	\$738
Number of advertisers	19	19
Receipts from advertisers.....	\$417 50	\$520 83
Total pages in JOURNAL.....	968	1,062
" " of papers	638	738
" cost of JOURNAL.....	\$3,140 43	\$3,462 08
Cost per page	\$3 24	\$3 26
Average number of copies issued monthly.....	1,796	1,845
Number of small cuts.....	57	166
" " plates and full-page cuts.....	45	42
Cost of illustrations	\$503 85	\$729 38



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HISTORY AND SELECTION OF STREET PAVING IN THE CITY OF NEW ORLEANS.

BY A. C. BELL, MEMBER OF THE LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, December 12, 1898.*]

GEORGE W. CABLE, in an historical sketch of New Orleans, thus describes its site and origin:

The Mississippi River, between the States of Mississippi and Louisiana, flowing at first southward, touches, on its eastern side, at the city of Vicksburg, a line of high, abrupt hills or bluffs, the eastern boundary of its later alluvial basin. The direction of this bluff line is southwesterly; and the river, turned from its southward course by it, flows in this new direction, occasionally impinging upon the abrupt barrier, as at Grand Bluff, Natchez and Fort Adams, and presently turns again with the bluffs, more directly towards the south, striking their base and swinging off from it at Tunica, at Bayou Sara, and finally at Baton Rouge.

Just beyond this point the bluff line swerves rapidly to a due eastward course, and declines gradually until in the Parish of St. Tammany, in Louisiana, some thirty miles from the eastern boundary of the State, it sinks entirely down into a broad tract of wet prairie and sea-marsh; the mainland coast of various inlets from the Gulf of Mexico. It is the general belief that this line of elevated land, now some eighty to ninety miles due north of the Louisiana coast, was the prehistoric shore line of the Gulf.

Close under the Mississippi bluffs, where they make their short turn to the east, the Bayou Manchac, once the Iberville River, and a chain of lakes—Maurepas, Pontchartrain and Borgne—connected by navigable passes and rigolets, formerly (until the obstruction of Bayou Manchac by the military forces of the United States in 1814) united the waters of the Mississippi River with those of Mississippi Sound. Meanwhile the river itself, turning less abruptly and taking a southeasterly course, cuts off between itself and these lakes a portion of its own delta formation.

*Manuscript received January 21, 1899.—Secretary, Ass'n of Eng. Socs.

This fragment of half-made country, comprising something over 1700 square miles of river shore, swamp and marsh lands, was once widely known as Orleans Island.

In outline it is extremely irregular. Its most regular boundary, that of the river bank, is very tortuous, while its width varies, even in its older portions, from fifty-seven miles across the Parishes of Plaquemines and St. Bernard to less than five miles from the river at English turn to the margin of Lake Borgne; another narrow region is seen between the river and Lake Pontchartrain, where these two waters approach to within six miles of each other.

This occurs at a point almost equally distant from the closed entrance of Bayou Manchac, the upper end of Orleans Island, and its lower end at the mouth of the Mississippi. In other words, it is one hundred and seven miles above the point where the waters of the river finally meet the sea at the outer end of Eads' jetties, in latitude $29^{\circ} 56' 59''$ and longitude $90^{\circ} 04' 07''$ west from Greenwich; distant 1242 miles by river or 700 by rail from St. Louis; 1760 by sea or 1377 by rail from New York; 4800 from Liverpool, and 4800 from Havre. On this spot, in February of the year 1718, was founded the city of New Orleans.

This site, which Bienville had chosen a year before, offered, to a superficial glance, but feeble attractions. The land, highest at the river's edge, where it was but 10 feet above sea level, sank back within the course of a mile to a minimum of a few inches. It was covered, for the most part, with a noisome and almost impenetrable cypress swamp, and was visibly subject to frequent if not annual overflow. One hundred miles and more lay between the spot and the mouth of a river whose current, in the time of its floods, it was maintained no vessel could overcome.

But the sagacity and Canadian pioneer craft of Bienville had seen its advantages. The Bayous St. John and Sauvage, navigable by small sea-going vessels to within a mile of the Mississippi's bank, led by a short course to the open waters of the lakes, and thus to the streams emptying into those lakes on their farther side, to the countries pierced by these streams, and eastward through the same lakes to Mississippi Sound and the Gulf of Mexico. On the opposite side of the Mississippi another easy avenue to and from the sea was presented by Bayou Barataria, and the network of streams and bays of which it forms a part. By the same waters the wide countries of the Atchafalaya, the Attakapas and the Opelousas were also made accessible, while northward the Mississippi and its great valley stretched beyond known limits.

Here, therefore, M. de Bienville decided to establish the port which later became his capital, and placed a detachment of twenty-five convicts and as many carpenters, who, with some voyagers from the Illinois, made clearing and erected a few scattered huts along the bank of the river.

In 1721 warehouses had already been erected, and Bienville, in certain governmental regulations, reserved the right to make his residence in the new city. During the year 1722 the seat of Government was transferred from Biloxi to New Orleans, and at that time the town contained 100 houses and 300 inhabitants.

The cession of Louisiana (of which New Orleans was the capital) by the French to the United States, in 1803, placed this city under American control. The population at this time was 10,000.

The exports exceeded in value \$2,000,000, and the imports reached the sum of \$2,500,000. The houses numbered about four thousand; the streets were straight, fairly spacious, but unpaved, ill-drained and filthy, poorly lighted and often impassable to vehicles by reason of the mire. The unpaved sidewalks were commonly bordered by wooden ways of four or five feet in width, while a few in the heart of the town had narrow walks of brick.

The year 1820 found the city with a population of 41,000. The inhabitants were realizing the necessities for improvements. The ancient parallelogram of ditch and palisades that had so long marked the city's ultimate bounds had disappeared in 1808, and the town was spreading far beyond it on every side. Improvements were being rapidly made in the narrow streets of the old town, as well as in the broader ones of the suburbs; and halls, churches and schools, stores, warehouses, banks, hotels and theaters went up in rapid succession.

These improvements and the growth of the city called for the paving of the streets, which, up to the present time, were unpaved, with the exception of Gravier street, between Tchoupitoulas and Magazine streets, which had been paved in 1817 with cobblestones; this material being brought by sailing vessels as ballast.

This square of paved street having proved such an improvement over the unpaved ones, and demonstrated that the streets could be paved, notwithstanding the yielding nature of the soil, we find that in 1820 the wooden sidewalks and curbs on the main thoroughfares gave place to others of brick and stone; and in 1822 a general paving of the principal commercial streets, both in the old and new town, was begun.

The experience with paved streets having proved satisfactory, and demonstrated to the public that streets could be paved on our soft soil, the City Council, September 22, 1827, passed an ordinance for the paving of streets and the making of sidewalks in the city of New Orleans and its incorporated suburbs.

The ordinance being too lengthy to be embodied in this paper, I will give a synopsis of the articles relating to paving.

Article I provided for a tax on all immovable property within the incorporated limits, to be paid at once by all owners fronting on streets and sidewalks already paved, by other owners, three months after the paving was completed.

Article II provided that the City Surveyor should assess this tax according to actual cost, two-thirds of which to be paid by owners and one-third by the corporation.

Three methods of settling for this paving were given the property owners.

First. The City Surveyor was instructed to add 8 per cent. per annum for twenty years on actual cost of paving, one-twentieth of the total to be paid annually for twenty years.

Second. Option was given to the owners to pay the actual cost in cash.

Third. The actual cost in notes, payable in six, twelve, eighteen and twenty-four months, with interest at 8 per cent.

Article III explains the division of cost of pavement of streets and sidewalks to be never more than one-third to the city when property on both sides of street is private. In cases of improvements in front of public buildings or city property, then the city to pay two-thirds, or the total of the cost, as the case may be.

Article V states that all owners who have already paved their sidewalks satisfactorily shall be reimbursed in proportion to present ordinance.

Article VI. On the petition of two-thirds of owners the corporation must proceed to pave according to Articles I and II of present ordinance.

Article VII. The city pays the total cost of all intersections.

Article VIII lays out the progress of the work for paving sidewalks, until full completion of all sidewalks within the corporate limits.

Article IX provides that all moneys received from owners in the original town shall be disbursed within the original town; all moneys received from owners in the suburbs shall be disbursed within said suburbs, in accordance with an ordinance of September 8, 1827, authorizing the borrowing of \$50,000 for paving improvements within the original city only.

Article XI. Paving of streets and building of banquettes shall be adjudicated to the lowest bidder by the Mayor, all materials being furnished by the corporation.

Article XII. The City Treasurer shall collect the taxes, notes, etc., provided for this ordinance; he shall keep a separate account and see that none of these funds be employed for any other purposes than paving of streets, construction of sidewalks and purchase of material for same.

The material used in street paving under this ordinance appears to have been shell, cobblestone, square block and flat stone, which, from the description, must have been curbstone laid flat on the street surface. The first time the use of planking for street paving is mentioned is in 1837, when an ordinance was

passed for paving certain streets with flatboat gunnels. This method of covering the mud streets must have been used at an earlier date, as the flatboats used for floating down the river the products from the country above furnished the material at a very reasonable cost, these boats being broken up at the end of their voyage.

In 1838 an effort must have been made to determine the relative merits of street paving materials, as an ordinance passed February 27, 1838, provides "that St. Charles street, from Poydras street to Girod street, be paved in the following manner: One-third in stone blocks, one-third in curbstone laid flat, one-third in hexagonal blocks of pine wood." The stone and wood blocks evidently proved satisfactory, as their use was continued as a paving material.

During the years 1827 to 1880, inclusive, the records show that a large number of streets in the area bounded by the river, Felicity road, Basin and Esplanade streets, were paved, and a few of the main streets parallel to the river were paved as far as the upper limits of Lafayette, or to Toledano street; and some of the streets leading from the river were paved as far as Metairie road. Only two roads were paved to Lake Pontchartrain, one along the west bank of the New Basin and the other along the east bank of the Bayou St. John.

The character of pavements laid during this period was plank-ing laid on stringers, shells, cobblestones, flat stone, square blocks and wooden blocks. Shells were used on the roads in the suburbs, and the other material was used in the urban part of the city where traffic was heavy.

The following tabulated statement shows the length and character of the pavements laid up to the year 1880:

Character of paving material.	Miles.
Plank road	4.88
Shell	23.54
Cobblestone	32.94
Stone blocks	22.06
Broken stone	8.87
Nicholson (wood block).....	1.66
Total	93.95

The estimated unit cost of each is as follows:

Plank road, per 1000 feet, board measure.....	\$18.50
Shells, per running foot of 20 feet width.....	2.25
Cobblestone, per square yard.....	2.25
Stone blocks, per square yard.....	4.75
Broken stone, per running foot of 20 feet width.....	2.25
Nicholson, per square yard.....	3.40

The total length of the streets of New Orleans was 566.29 miles, of which 472.34 miles were unpaved, or about 83 per cent. The population at this time was 216,000, and the value of exports amounted to \$90,238,503 and the imports to \$10,611,353. Asphalt, or a paving material which at that time was called asphalt, was laid in 1880 on Gravier street, between Front and Delta streets. The life of this pavement was short, as it soon went to pieces under the heavy traffic to which it was subjected.

The Cotton Centennial, held in 1885, at what is now Audubon Park, forced upon the city the necessity of paving St. Charles avenue, one of the principal avenues of the city, and the only means of access for vehicles to the exposition grounds. The material selected was asphalt, and the close of the year 1885 found St. Charles avenue paved with this material on both roadways, from Delord, now Howard avenue, to Louisiana avenue, and the river roadway to Carrollton. This material, owing to its durability, smooth surface and excellent sanitary qualities, at once found favor with the public, and has so continued to this day.

The year 1889 marks the introduction of concrete gravel pavements, and during the years 1889 to 1896 a large number of streets in the Fourth, Sixth and Seventh districts were paved with this material. These districts had already commenced to show improvement, but with the advent of this pavement improvement was rapid, due in large measure, I think, to the betterment of the streets. The selection of this material and the paving with it of so many streets proved unfortunate, to say the least. The material was concrete in name only, and the result is that to-day we have a large mileage of street pavement, for which large sums have been expended, which are but slightly better than the old dirt streets which they replaced. However strongly we may condemn gravel as a paving material, this should be placed to its credit: that while it remained in good surface it served as an illustration of the benefits to be derived from well-paved streets.

Vitrified brick was first laid in this city in 1894, being laid in the First, Second, Third, Fourth, Fifth and Sixth districts.

In 1895 chert pavement was introduced; but a small amount has been laid, two streets in the First and two in the Sixth district having been paved with it.

Street paving is carried on by special assessment levied on the abutting property, three-quarters of the cost in the case of ordinary streets, and two-thirds in the case of neutral ground streets; the city paying the other one-quarter or one-third and the whole cost of intersections.

The Council can, in the matter of repaving of streets, order the work done at the cost of the city. The legislation is by petition, signatures of property owners to the amount of one-quarter of the total front footage being required. Protest requires the signatures of a majority of property owners by foot frontage. By a two-thirds vote, the Council can require the paving of a street, the cost to city and property owner being prorated as indicated above, according to the character of the street, whether ordinary or neutral ground streets.

As the construction of the pavements that have been mentioned in this historical sketch may not be familiar, I will endeavor to illustrate their construction.

Plank road. This pavement (if it can be so called) was constructed by bedding in the sub-grade stringers 4 x 8 inches or 4 x 12 inches, spaced 4 feet apart, and laid longitudinally of the street; on these stringers were placed transversely of the street planking 2 x 12 inches or 3 x 12 inches, securely spiked to the stringers; the material used was either yellow pine or cypress.

Cobblestone pavement. This pavement was constructed by thoroughly compacting the sub-grade after it had been brought to the proper surface, and then spreading on this six inches of river sand, in which the cobblestones were bedded and thoroughly rammed.

Square block. This method of paving consists of the preparation of the sub-grade to a uniform compact surface by excavating and thorough tamping or rolling; on this sub-grade is placed four inches of river sand, in which the stone blocks are bedded and rammed into position. The blocks are of granite, about 10 x 14 x 8 inches in depth; the joints between these blocks are from three-quarters to one inch in breadth, and are filled with fine gravel.

Belgian block pavement consists of the preparation of sub-grade as previously described; on this sub-grade is laid six inches of concrete and on this two inches of sharp sand, in which the blocks are bedded and rolled with a heavy roller, or rammed; the joints are partly filled with fine gravel and then filled with paving pitch. The blocks are of granite, 4 x 10 inches and 5 inches in depth.

Vitrified brick. The preparation of the sub-grade and laying of concrete and sharp sand, and bedding the brick in same, is as described for Belgian block pavement; the joints are filled with either paving pitch or cement grout.

Asphalt pavement. Preparation of sub-grade and laying of

concrete foundation same as for Belgian block and vitrified brick; on the concrete foundation is laid a binder $1\frac{1}{2}$ inches thick, and on this the wearing surface, 2 inches thick, of asphalt is laid.

Wood block pavement consisted of a thoroughly compacted sub-grade on which was laid 1 x 12-inch tarred planking. The wood blocks of heart pine, after being dipped in hot tar, were then placed on this planking and the joints filled with fine gravel and pitch.

Shell roads consist of a thoroughly compacted sub-grade on which is laid 6 inches of oyster shells, which are rolled with a heavy roller; on this is then spread 6 inches of lake shells, which are rolled with a heavy roller to a uniform surface.

Gravel and chert are paving materials which are treated in the same manner in the construction of a roadway, and the same description will answer for both. The sub-grade is excavated to proper depth and compacted by rolling or tamping; on this sub-grade is laid 1 x 12-inch cypress planking, and on this is laid the first layer of paving material 6 inches thick, which is sprinkled and rolled; the pavement is completed by the addition of two more layers, each 3 inches in thickness, sprinkled and rolled, the last layer being compacted by successive sprinkling and rolling until a compact uniform surface is obtained. The following tabulated statement shows the character and mileage of the street pavements in the city of New Orleans to August, 1898:

Character of paving material.	Miles.
Plank roads.....	40.64
Cobblestone	40.49
Square block.....	26.14
Belgian block.....	2.32
Vitrified brick.....	5.83
Asphalt	11.98
Wood block.....	0.06
Shell roads.....	21.83
Gravel roads.....	42.55
Chert roads.....	2.78
Total	194.62

The estimated unit cost of each is as follows:

Plank road, per square yard.....	\$0.56
Cobblestone, per square yard.....	2.00
Square block, per square yard.....	5.00
Belgian block, per square yard.....	4.25
Vitrified brick, per square yard.....	2.50
Asphalt, per square yard.....	3.10
Wood block, per square yard.....	3.40
Shell roads, per square yard.....	1.00
Gravel roads, per square yard.....	1.50
Chert roads, per square yard.....	1.75

At the present time the total length of the streets open to use is 700 miles, of which 505.38 are unpaved, or about 72 per cent. The population at the present time is 275,000, and the area in which the streets are opened is 20 square miles; the area protected from overflow by levees is 39 square miles, and the total area in the incorporated limits is $196\frac{1}{4}$ square miles.

It is interesting to note the gradual expansion of the city from a small hamlet containing one hundred houses to its present size. In 1728, ten years after being established by Bienville, it contained an area of 3-16 square miles; in 1798 the area was 5-16 square miles, and in 1815 the area was $1\frac{3}{4}$ square miles; in 1841 the area was $3\frac{1}{4}$ square miles; in 1871 the area was $15\frac{1}{8}$ square miles.

A history of the street paving of a city naturally brings up for discussion, "What is the most suitable pavement for the variety of conditions that are found in the streets of a large city?"

As illustrated in the historical part of this paper, in the early times availability generally determined the kind to be used, but as our cities increase in size and importance, and the varying conditions governing the use of the streets become more complex, the question of a suitable pavement for the different conditions becomes a vital one, and has received and is now receiving serious consideration. This problem is not easy of solution, as a pavement that may suit some conditions will not suit all.

Mr. Geo. W. Tillson, member of the American Society of Civil Engineers (who has given the subject of street paving much study), read before the Washington convention of the American Society of Municipal Improvements, October, 1898, a paper, entitled "A Study of Paving Materials," which contains so much valuable information on this subject that I feel justified in quoting from same:

A perfect pavement should be cheap, durable, easily cleaned, present little resistance to traffic, not slippery, cheaply maintained, favorable to travel and sanitary.

The question of first cost is very important. As with individuals so it is with corporations; what is not economical in the end must often be given up and an inferior article adopted, because the available funds will not permit the required outlay. If the best cannot be used the one nearest to it must be taken, provided it comes within the appropriation. An advocate of a new paving material is almost invariably met with the question, What will it cost? If the price be extreme he will have a hard task to introduce it, no matter how great his other attractions may be.

Durability is probably the most important quality of any material. Ultimate cost depends as much upon this as upon first cost. No matter how cheaply a pavement may be laid, or how pleasing it may be, if it require constant and frequent renewal its real value is greatly diminished. This is especially true in large cities, as the delay and inconvenience to

business on a crowded street may often amount to more to abutting tenants in dollars and cents than the actual cost of the pavement. In a country, too, like America, where the tendency is to build and then allow repairs to take care of themselves, durability is most important.

The growing demand for clean streets in our cities has brought into prominence any pavement that can be easily cleaned. What this amounts to in money can be appreciated by a statement made in December, 1896, by Colonel Geo. E. Waring, Jr., at that time Street Cleaning Commissioner of New York City.

At a meeting of the American Society of Civil Engineers, he said that if all the streets of New York were paved with asphalt, where the grades would permit, and the street car tracks constructed with grooved rails, the cost of sweeping the entire city would be reduced from \$1,200,000 per annum to \$700,000. That is, there would be a saving annually of \$500,000, which, capitalized at four per cent., would amount to \$12,500,000 in a city that at that time had a pavement mileage of 431 miles, of which ninety-four were already paved with asphalt.

Resistance to traffic is an important item. In fact, one of the chief provinces of a pavement is to reduce this, and consequently a pavement that can bring this to a minimum is of particular value. A mechanical device that would reduce the friction of a machine fifty or even twenty-five per cent. would be of incalculable benefit, yet a good pavement on a street accomplishes this. It makes one horse do the work formerly performed by two.

The slipperiness of a pavement depends primarily upon its material, but a great deal depends upon its condition. The former will be considered here.

The efficiency of a draft horse must vary with his foothold. If it be good he will be able to use his entire strength to draw his load, while if he be in constant danger of slipping and falling he can accomplish very little.

The relative slipperiness of the different materials often has been discussed. It varies greatly with its condition. For instance, asphalt is more slippery when it is dirty and wet; granite when it is clean and dry. Extended observations were taken in London by William Haywood, engineer of the Commissioner Sewers, in 1873, to determine the number of accidents occurring on different pavements. From his results he deduced that a horse would travel 132 miles on granite, 191 miles on asphalt and 330 miles on wood without having an accident of any kind.

In 1885, Captain, now General, F. V. Greene had a series of observations made in ten of the principal cities of this country for the same purpose. From these he decided that in the United States a horse would travel on wood 272 miles, on granite 413 miles and on asphalt 583 miles without an accident. In both of these cases the falls were divided into those upon the knees, the haunches and complete falls. Falls upon the knees on a rough pavement should not wholly be charged to slipperiness, as a great many must have been caused by stumbling. Captain Greene found that of a total of eighty-four falls, sixty-eight were upon the knees; assuming that one half of the latter were stumbles only, the deduction would be that a horse would travel 668 miles on granite without an accident due to slipperiness. These results of course are general.

Maintenance is closely allied to first cost unless it be known and considered in the adoption of a material, a choice cannot be made intelligently. What seems to be sound selection will often be ruled out by the cost of repairs. Any material will require constant attention, but that one which needs the least and permits that to be done with the least inconvenience to the public is of most value.

By favorable to travel is meant the ease and comfort that is enjoyed in driving over a smooth pavement, and the decrease in the wear and tear of vehicles and horses. No attempt ever has been made to measure this in actual money, but it is known to be great. It is a pleasure to drive over some pavements, and actual pain to drive upon others. As our streets are for enjoyment as well as use, this property must be considered. The large number of bicycles constantly on our highways makes this especially important.

Another function of a pavement is to preserve health. In large cities it is impossible to prevent decaying matter from being deposited in our streets. If a pavement be of such a character that any of this collects in joints, so that it is not removed by the street cleaners, it cannot but be very deleterious to the general health.

Consequently a pavement that is impervious to water, has a smooth surface and is not itself composed of organic matter will be sanitary.

Noise, too, must be considered. A noisy pavement prevents sleep, rasps on the nerves of the sick and prevents conversation on the street. This question of noise is of such importance that in Greater New York estimates have recently been made for repaving around all schoolhouses in the city with a smooth and comparatively noiseless material.

Mr. Tillson in his paper assigns an arbitrary value to the different qualities required of pavements as previously enumerated, and by deduction determines the pavement suitable for the conditions found on any street. Using the qualities outlined in Mr. Tillson's paper, I will endeavor to determine the most suitable pavement for the various conditions imposed by our business, residence and suburban streets. Eliminating from the discussion planking and cobblestone as being obsolete, the discussion then assumes this form: The use of square block or Belgian block for streets in the business section subjected to heavy traffic; asphalt and brick for streets in the business section subject to light traffic, and also for residence streets; gravel, shells and chert for suburban streets.

Square block is expensive in first cost of construction; if kept in proper surface and repair, expensive to maintain, and therefore not durable; owing to the large joints and the lack of cohesion of the filling, it is a pavement difficult to keep clean, and therefore unsanitary, as the joints retain any deleterious material that may be swept into them. The surface not being uniform, it offers great resistance to traffic. The large area of surface of the blocks, which soon become smooth and polished under traffic, renders this class

of pavement very slippery. It is therefore evident that square block possesses none of the qualities of a good paving material, and should be rejected.

Belgian block, owing to its method of construction, has all the qualities of a durable pavement; easy of maintenance and offering but little impediment to cleaning, and therefore in a measure sanitary. Owing to the small size of the blocks and the number of joints, it offers a better foothold to horses, and is therefore nearly free of slipperiness. The objections to be urged against it are that it offers considerable resistance to traffic and is very noisy. but these objections are minor considerations in streets of the business section devoted to heavy traffic. Belgian block should therefore be selected for this service.

Asphalt and vitrified brick. The distinction between these two paving materials is so slight that it is difficult to make a selection. One is equally as durable as the other; cost of maintenance is about the same. Brick is not as slippery as asphalt, but asphalt is more easily cleaned, offers less resistance to traffic and is more sanitary than brick. With our present prices the cost of asphalt is less than brick; but, even were the case reversed, asphalt should be selected for our retail business or residence streets.

Gravel, chert and shell. As these materials are only suitable for suburban streets, the qualities necessary to be considered are durability, resistance to traffic and maintenance. Our experience with gravel has been so unsatisfactory it should certainly be rejected. Experience with chert has shown it to be durable and easily maintained under light traffic, and offers but slight resistance to traffic. Shells are not durable, pulverizing under traffic, and the dust is blown and washed away. This loss of the material increases the cost of maintenance. The resistance to traffic is great, owing to the size and shape of the shell and the lack of cohesion of the material until it has become thoroughly pulverized. The first cost of chert is greater than that of shell, but, owing to its slight cost for maintenance and light resistance to traffic, the choice should rest with chert for suburban streets with light traffic.

Having determined on the character of the paving material to suit the conditions found on the different classes of streets, the next problem that confronts the municipal engineer is to ascertain that he gets the material specified, and in the proportion asked for. This can only be accomplished by rigid inspection. The lower grades of pavements can be inspected by observation on the work, but the higher grades, such as Belgian blocks, asphalt and brick, and the concrete foundations of same, can only be determined by

physical and chemical tests. A testing laboratory is therefore a very essential part of the equipment of any municipal department having charge of the construction of public works.

Asphalt, up to a few years ago, was laid by one or two companies, who obtained their material from the same source; and, as it was of the same quality, similar methods of manipulation were followed, and the resulting pavements were satisfactory.

At the present time new sources of supply have been developed, and new companies are entering the field. The engineer's knowledge of this material and its manipulation must be equal to that of the contractor or his experts. This technical knowledge is absolutely necessary to properly guard the interests of the municipality, both in the preparation of the specifications governing the work and the determination of the character of the material and the ability of the contractor to properly manipulate the material and furnish a satisfactory pavement.

It may be urged that pavements are laid under a guarantee, but why should a city be content with a pavement that may last five years if, by proper inspection, the life may be increased to eight or even to ten years; and if, with the knowledge thus obtained, the city may be enabled to make her own repairs if she so desires?

This acquisition of knowledge of the material and its manipulation broadens the field of competition, and, as has been truly said by an expert on this subject, "there is no more reason why a few people should control, through their superior knowledge, the laying of asphalt from Trinidad and other sources of supply than that a similar number should control all the rubber that comes from Para for the manufacture of bicycle tires."

Washington and Brooklyn are both equipped with testing laboratories, and the improvement in their street work and their increased knowledge of paving materials attest the value of the system. The Washington authorities have established standards of material for contractors, and their dictum is never questioned. They assume to know as much as or more than the contractors, and the results have proved the assumptions to have been correct. They did not hesitate to condemn an entire cargo of asphalt. They won the respect and confidence of the contractors by doing and being right.

THE UNITED STATES NAVY.

Personnel Reorganization its Greatest Need.

BY WILLIAM B. COWLES, MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read before the Club, January 24, 1899.*]

THROUGHOUT that great area of our country populated since 1812 and lying between the Blue Ridge and the Sierra Nevada the United States Navy has been heretofore almost an unknown quantity. Americans within this area had hardly given it a thought, except as a matter of dry statistics of State, generally overlooked, unacknowledged and entirely foreign to their sphere of life.

It was very different with regard to the army. With the exception of the War of 1812 and the small operations against the Barbary States, our wars had been entirely within our borders or on adjoining land, and were confined to army operations, the fleet being an adjunct. Ex-officers and men of the army had absorbed a large and deserved share of public attention and emolument; military posts were scattered throughout our domain, and hardly a family North or South was without its military record or tradition. In fact, we knew and were part and parcel of the army, and had practically forgotten the importance of the navy, because the latter did not enter our inland life, and its bearing on international affairs and trade had not been forced upon our attention. The time had not come for us to "take our place among nations"; we were engaged in the development of our great inland domain and in domestic commerce; railroads and the changes they brought absorbed our thought; the sea was to us but a vague geographical fact, and not a vital element of our prosperity. The American clipper, once known wherever tides rolled, had been chased from beneath the stars and stripes by the "Alabama" and the "Shenandoah," and bad laws, together with the lack of good ones, had prevented its return. International communication, imports and the export of our immense food products were almost entirely in the hands of foreigners, and we were willing they should remain there; our manufacturers rather sneered at foreign markets; they seemed satisfied with supplying the home demand; and lastly, our laws did not favor or encourage the deep sea shipowner, though they made a point of searching out and nursing almost every other possible industry, large or small.

*Manuscript received February 6, 1899.—Secretary, Ass'n of Eng. Socs.

The common and derisive question of the inland Congressman, typical of his constituency, was, "What do we want a navy for, anyway?" and the question went unanswered, or badly and ignorantly answered, because the American people were still in a state of national adolescence; too busy getting their growth. They could not realize that the time was soon coming in their history when, as with trading Britain, sea power must be the mainstay of their prosperity and the bulwark of their defense.

But all this is changed. The epoch-marking year of 1898 saw the sentiment of the nation awake with a bound to the need of a navy and the emergency uses of a merchant marine, and to the fact that we had both navy and merchant marine, small to be sure, but still permeated with the immortal spirit of 1812.

To one who had known the navy and the merchant marine intimately from boyhood, it was a glad sight, last May, to see the men and ships of our national fleet reinstated in their rightful place in the affections and appreciation of his countrymen.

The growth of sea power among leading nations throughout the world is the most momentous fact of current history, and the logic of events has now forced a strong naval and merchant marine policy upon our country. If we would hold our own and take our destiny in hand, we must have a navy and a merchant marine commensurate with our commerce and our geography. Every ship bearing our flag abroad is a knight-errant of civilization and a missionary of trade; but she is far more even than this,—she floats a living element of our defense and of our power to deal justly among nations.

The merchants of England certainly understand some of the axioms of foreign trade. There is one thing at least which we can safely learn from the business men of England without waiting to have it hammered into us by hard knocks in the new field of foreign relations and commerce upon which we are now entering. Anything which tends to the efficient maintenance or betterment of the Royal Navy and British merchant marine commands the lively interest of merchants, manufacturers and engineers throughout that empire; and this with them is a matter of business as well as of patriotism, for it concerns them vitally in their colonial and foreign trade, and, in its reflex action, their domestic affairs. The Royal Navy always stands first and foremost in the care of the British nation, and this for the very substantial reasons just stated. Some such thought and interest must be given our own little navy and merchant marine, if we are to attain and hold our natural and fitting position in international commerce.

Cleveland is far from the sea, you say? No, it is within a short step, and our most inland factory is now rapidly growing nearer to the seacoast in a commercial sense; the ordinary business thought and customs of the last decade are fast becoming a misfit in this respect.

No American manufacturer can now pull his cloak about him and safely say, "I have nothing to do with the sea," for, let him look to it, the influence of the sea and sea power will surely affect him vitally in some manner, and that soon.

How many members of this community are now directly interested in furnishing naval or merchant ship matériel? How many more members are indirectly affected by contracts for such matériel? How many members can say that their business is entirely unaffected by the naval power and merchant marine of this country, by shipbuilding, or by the sea and its trade? Or am I asking these questions a few years too soon? The manufacturers of this country have barely entered the foreign markets, and we have but just commenced to build foreign warships; the time is plainly in sight when we can build not only the fleets which carry and protect our own commerce, but a large part of the fleets of the world. This is not buncombe; it is a legitimate business forecast. It should need no further argument to show that the betterment of our navy and merchant marine is and should be our especial interest.

I have referred to naval and merchant ship matériel; the following table is accurately condensed from "Brassey's Naval Annual," the "U. S. Naval Register" and "The Statesman's Year Book," all of 1898:

Country.	Sea place.	Modern naval ships, over 1000 tons displacement. Built, building, pro- posed; '98-'99.		Merchant steamers; ex- cluding river steamers and small craft. Statis- tics of '95-'97.	
		No.	Displacement.	No.	Register tonnage.
Great Britain.....	1	287	1,810,050	8,522	6,284,306
France	2	129	741,513	1,235	503,667
Russia	3	96	546,112	522	205,649
Germany	4	84	422,549	1,126	889,960
United States	5	77	395,406	5,551	2,183,512
Italy	6	63	330,970	345	220,508
Japan	7	39	205,518	827	213,221
Austria	8	33	125,339	202	146,098
Netherlands	9	39	109,188	172	196,824
Brazil	10	16	44,313	189	75,283
Denmark	11	17	41,107	445	176,845
Argentina	12	12	39,797	75	21,613
Chili	13	9	39,000	42	29,931
Sweden	14	14	33,906	118	93,653
Norway	15	12	25,797	237	262,950

The recent naval increase of the youngest and the oldest nations in this list is remarkable:

	United States.		Japan.	
	No.	Disp. tons.	No.	Disp. tons.
Sea place in 1896.....	6	.....	8	.....
Available Navy, January 1, 1899.....	50	185,381	26	92,362
Building and projected, 1899.....	27	210,025	13	113,156
Sea place with last additions.....	5	.....	7	.....

In addition to the figures above given the United States Navy had, on July 1, 1898, 47 auxiliaries, with a displacement of about 255,000 tons. When our present program becomes effective we shall be a good fifth, and about equal to Germany if we then have a commensurate merchant marine to draw auxiliaries from. Our sea place should be at least fourth if not third, and coming events, now casting their shadows before, will probably force us to take that place from business and trade necessity, no matter how we ultimately decide as to what has lately been called "imperialism." If this be doubted, we have only to study the merchant ship columns of the table and compare these with the naval columns, using business sense and remembering geography.

The figures given for American merchantmen are those of 1895-6; what they will be in 1901-2, when our present naval program and adequate merchant ship laws become effective, is another matter. We may even deduct say 800,000 tons for lake tonnage in making the sea comparison, but can we say how much of this lake tonnage will remain purely lake tonnage in the near future? Already (and before Canadian canal improvements that are surely coming soon) a considerable proportion of the small lake craft are in winter service at sea. This is a natural and perfectly feasible movement, sure to increase.

Our recent disagreement with a sixth-rate foreign power has shown some lines of needed improvement in our naval matériel: Water tube boilers are here to stay; there will be a minimum use of wood, and that used will be non-inflammable; cruising ships will be wood-sheathed and coppered; "nurse ships" will be a regular part of every future squadron or fleet; to repair, to coal and water, to receive the sick and wounded and for many other like purposes. The little torpedo boat will cut less of a figure; large destroyers, with sustainable capacity for scouting and dispatch service, will be more in favor. Smokeless powder is a necessity.

Application of rapid fire breechings to heavier calibers and an increased muzzle velocity will be sought and gained in ordnance. Higher squadron speeds and manœvering powers will be sought, resulting in more uniformity in fighting ships.

A cloud of details in construction, ordnance, armor, steam, hydraulic, pneumatic and electrical engineering and equipment has now, by experience, been condensed into the proof-liquor of practice, or blown away as experimental vapor; the short squall has cleared the atmosphere, and we shall have fewer "frills" and more solid fighting sense in the matériel of our warships, though the latter has always predominated.

Our naval matériel is now second to none in quality; it will be still further improved and its quantity will doubtless be brought up to our necessities, for the reasons stated.

It is easy to show figures and facts and make arguments in support of our naval matériel, for general engineering knowledge and public appreciation are now, happily, in a state to receive and understand the facts; but it is far more difficult when we approach the subject of naval personnel, for this still seems to us unknown.

To be sure we have heard about the "man behind the gun"; the "poor devils in the fire room"; the "marines at Guantanamo," and there are two or three names of individuals which have now become household words. But what do we know of the 1327 regular commissioned officers of the navy on the active list, July 1, 1898, as to their effective relations to each other, to the warrant and enlisted force and to the matériel? I venture to say that we know practically no more than we do about the personnel of that questionable fleet which operated against Troy. And yet this body of officers constitutes the most important part of our navy; they are its "gray matter" and vital force; without them our famous fighting ships would be but painted toys upon a painted sea, and our merchant marine a babe unswathed. Whatever affects the personnel affects the navy in head and heart; whatever tends to improve the personnel strengthens the navy more than battleships. What better proof can we have of this than was furnished us on July 3 last? The failure of the Spaniards to put up a better fight and race was not due to lack of matériel nor lack of bravery; it was distinctly due to lack of unanimity, organization and training in their personnel. And this is directly chargeable, not to the Spanish navy, but to the unspeakably foolish and ignorant policy of the Spanish Government in failing to organize and train its brave naval personnel on a modern basis and in the light of modern progress. The Spaniard provided himself with modern tools and used them with the knowledge of the sixteenth century; he despised the engineer as being beneath the spirit and tradition of that fighting chivalry which once enslaved the world, and he suffered the consequence. The Spaniard could not be a mechanic

himself; he hired foreign mechanics in subordinate positions not homogeneous with his combative force; he therefore perished miserably. The Spaniard can live again if he will, but he must learn engineering and make it a unified part of himself,—there is no alternative but death.

The following table indicates how the personnel of our own navy is now arranged both in corps and rank:

REGULAR COMMISSIONED OFFICERS OF THE U. S. NAVY,
JULY 1, 1898.—ACTIVE LIST.

Corps.	Rear-Admirals.	Commodores.	Captains.	Commanders.	Lieutenant-Commanders.	Lieutenants.	Jr. Lieutenants.	Ensigns.	Totals.
Line	7	10	45	85	74	250	76	171	718
Engineers .....	..	1	10	15	5	75	22	52	180
Marines .....	..	1	1	2	7	22	30	9	72
Medical .....	..	1	14	15	..	50	53	28	161
Pay .....	..	1	12	13	20	20	20	25	111
Chaplains .....	..	..	4	7	..	7	6	..	24
Naval Constructors. .	..	1	1	3	..	11	19	..	35
Civil Engineers....	..	1	1	1	3	4	5	..	15
Profs. of Math's... .	..	..	3	4	..	4	..	..	11
Totals	7	16	91	145	109	443	231	285	
Grand total.....	1,327								

The first six corps may be called amphibious; their members are seagoing and also have important duties on shore in regular routine.

The members of the first three corps (line engineers and marines) have duties in charge of considerable bodies of enlisted men; the second three corps (medical, pay and chaplains) constitute the “non-combatants,” as the term was used in the old sailing days. The last three corps (naval constructors, civil engineers and professors of mathematics) are purely administrative and technical, and have to do entirely with matériel; their members have no regular sea duties after entering their corps, though most of the constructors and many of the professors of mathematics have served considerable periods at sea as young line or engineer officers.

The marines are that body of web-footed soldiers which has remained on warships since the days of Drake, when all “combatants” were soldiers and sailors were only carried to navigate the ships, not to fight. The marines fill a peculiar position; they have army pay and titles and are the policemen and watchmen of the navy, though on occasion they have promptly shown themselves to

be most anything and everything that happened to be needed at the moment in the purely fighting line. The corps is put in the table with assimilated rank to the other two "combatant" corps for the purposes of comparison.

Now as to the first two corps, the line and engineers:

I feel that my peculiar position as a graduate of Annapolis and an ex-officer of the navy lays upon me, as a citizen, a certain duty in this matter as being one of the few civilians who can speak with intimate inside knowledge of the navy.

In performing this duty I could urge upon you the justice of that cry for relief from antiquated conditions which has come these many years from your professional brethren in the naval service. I have consistently refrained from such action heretofore because, personally, I could not see that any of the several solutions proposed by either the line or engineers would really affect a permanent settlement and relieve our navy from certain long-standing troubles which have handicapped the efficiency of its personnel since the advent of steam navigation.

And now that the "touchstone" of homogeneity is found which can turn all this dross of discord into the pure metal of highest efficiency, I do not speak simply as an engineer and as an ex-officer; I choose the higher and broader ground of the loyal citizen who wishes to see our navy placed where the business interests and necessities of the country require it,—in a state of the highest possible service to the nation.

The present Naval Personnel Bill embodies a solution of difficulties which insures uniform justice to all corps and all individuals; which is accepted and urged by all parties in the navy (a thing heretofore unheard of); which offers a guarantee of permanently silencing the tiresome and narrow bickerings and shell-backed prejudices which have hurt the navy for a generation.

This bill (H. R. 10,403, 55th Congress) may be briefly summarized as follows:

1. Differences have existed, justly or unjustly, between the line and staff in regard to rank, pay and duty which have been a great detriment to the service by preventing homogeneity. These differences have been of late years principally between the line and engineers, because the evolution of the warship from the sailing vessel to the fighting machine has forced the members of both corps to become fighting engineers in spite of themselves, and with duties in very many respects practically similar. The ancient and arbitrary distinction of rank and pay was founded in sea-dog prejudice, and has been maintained in the face of progress until it

has become in these modern times a radical misfit, absolutely senseless and detrimental to efficiency. The differences in rank cause needless incongruities and complications in duty and unjust postponement of promotion; the differences in pay are alike unjust to the juniors of the line and the seniors of the engineers.

Both line and engineer officers actually command men in about equal numbers, and yet there is an antiquated statute which, whatever may have been its merits in old days, now flies in the face of fact and common sense by saying that the engineer officer does *not* "command" his men in working one set of machinery, while the line officer *docs* "command" his men in working another set of machinery on the same ship. In trying to explain this idiotic fetich to the uninitiated civilian reason rebels, and one can only state the fact. None but a mind trained from youth to illogical thinking can comprehend it. Some of the situations it produces are equal to those "upside down" affairs of "Alice in Wonderland." It is a veritable hidden cancer in the service, but the Personnel Bill will eradicate it without using the knife. The bill, by certain wise and feasible provisions, amalgamates the line and engineers into one corps.

2. Promotion in the lower and middle grades of the line and engineers has been for years so slow as to definitely reduce the efficiency of the service in addition to causing a great amount of positive injustice to officers in the prime of their usefulness to the country.

Officers are now kept in the grade of lieutenant until they are over fifty years old, and then are rushed with bewildering rapidity through the upper grades to the retired list. This is a foolish way to run our navy. We lose a large part of that vigor, snap and quick decision necessary to the commander of a warship, because men kept in subordination until they are forty-five or fifty years old generally lack these requisites. Unjustly slow promotion deadens ambition, drives many valuable men from the service and greatly handicaps those who remain. It is "penny wise and pound foolish" from an economical standpoint.

The bill, by certain wise provisions for "voluntary" and "selected" retirement, creates a uniform and healthy flow of promotion with justice to all and prevents the recurrence of congested points in the list.

3. The pay table provided by the bill is practically that of the army, grade for grade; it is eminently fair and consistent to the officers and is just to the country.

4. The bill gives rank and pay to the constructors in proportion to the high attainments and responsibilities of that very important corps.

5. The bill gives a much deserved reorganization and increase to the marine corps.

6. The bill gives much needed encouragement to the enlisted force by providing for possible promotion and a uniform retirement privilege after thirty years of faithful service.

Enough has been said to indicate the importance of this bill and its vital necessity in the policy of naval and merchant marine progress in which this country is now engaged.

This Personnel Bill is not political except in the broadest and best sense; it has been well fathered and well thought out; it is approved with practical unanimity from end to end of the naval service; its merit and its desert are unquestioned; it was passed by a decisive vote last week in the House; it should pass the Senate at this session of Congress. Its passage in the Senate depends largely upon the energetic action of the friends of the navy throughout this land and upon their urgent insistence that it should pass.

The very fact that this bill is non-partisan and that it especially benefits no individual politician or political faction throws the bill, to a large extent, directly upon the public-spirited interest of the citizen for its support. It has few enemies, and these are not very active, having no ground but antiquated prejudice to stand upon.

There is, however, a dangerous rock in the course of its smooth sailing to the safe harbor of the Revised Statutes; it may lack sufficient active and urgent friends in the Senate to secure its prompt passage; it may, therefore, die from suffocation and the press of other bills.

If individuals, corporate bodies and the press urge its passage and back up their Senators in urging its passage, the bill will probably become a law within two weeks; if this is not done, our deserving naval officers will be left to suffer indefinitely and the country will miss the homogeneity and efficiency which it should have in the naval service.

DISCUSSION.

MR. JOSEPH R. OLDHAM.—A short time ago I wrote to Senator Hanna and our Representative, Mr. Burton, asking their support with regard to this bill, and received a favorable reply from each. It is gratifying to note that they are in favor of the bill.

At present Great Britain has practically three times the mercantile tonnage of the United States. This was not always so;

shortly before our Civil War we had more tonnage than Great Britain. In 1861 we built more tonnage than Great Britain. Then we were adding more tonnage to our mercantile marine than all the rest of the world put together, and we are now trying to restore it to its original condition. In those days the ships were largely wooden ships. The new type of ship was beginning to gain favor at the beginning of the Civil war. Great Britain saw its opportunity, and its tonnage went up at once. The iron ships would carry from 15 to 20 per cent. more dead weight than the wooden ships. The British went on building very fast, and in a very short time they ran our vessels practically off the sea. Fifteen to twenty pounds of steam was then a common pressure. Compound engines were not heard of.

Great Britain carries 70 per cent. of the freight of the world. Last year we built 60,000 tons of steamships and Great Britain built 150,000. Shortly before the Civil War we carried 70 per cent. of the American exports and imports, and now we carry only 9 per cent. This shows the importance of the Government assisting our mercantile marine, and we shall never get a better bill than the Hanna Bill, which is now before the House.

It is not the mail steamers that make large profits; some of the fast lines pass some years without declaring any dividends. The freights are largely carried in tramp steamers, which make a profit of from 12 to 25 per cent. per annum. While Great Britain has a very large number of tramp steamers, there is not such a thing in the world as an American tramp steamer.

We as a club ought to consider very seriously what Mr. Cowles has said about engineers on sea vessels receiving their dues. We find an engineer and a captain sitting in the same office, but the engineer is always a subordinate. The reason for this is that when the master marine was first created there were no engineers, and he was everything. The master mariner can shoot a man if he is insubordinate, which is something that even the President of the United States or the Emperor of Germany cannot do. There is a glamour about him which the engineer has never enjoyed. The engineers on board vessels have been styled "bloody blacksmiths." This is hard on the engineers, and all we want is that they shall be fairly treated. It is only of recent years that engineers have been given the position of principal officer, and that only in a very few instances. We ought to do all we can to advance the standing of engineers in the mercantile marine and navy, so that they may occupy the positions which their abilities and arduous duties warrant.

MR. W. H. SEARLES.—The paper is very timely, as the bill to which it refers is now pending in the United States Senate. The Executive Board of this Club has already instructed its President and Secretary to communicate with our Senators, urging their earnest support of this bill, and these official letters have been sent. Letters from individual members of the Club might appropriately be sent, making similar request.

The table shows a great discrepancy in the tonnage of our navy and mercantile marine compared with those of Great Britain. If our mercantile marine is to grow, as we believe it will under the stimulus of the new conditions which have recently come to our country, certainly our navy should be brought up to a ratio more nearly commensurate with that of the mercantile marine.

As long ago as our Civil War I was in Washington and knew many men who were naval engineers. They were men of ability and fine families, and yet there was much friction between the line and engineer officers. It is time that the source of this irritation be removed, and I believe that the present bill will do all this, and that when it becomes law we shall have only harmony and a much better condition of service than ever before.

MR. C. W. HOPKINSON.—I have been following up the articles by Park Benjamin, published in a New York paper, and I would ask how it has been all these years in the foreign navies as to this difficulty between the officers of different corps. Has the question been solved?

A VOICE.—Is it not true that the great decrease in mercantile tonnage was due to the depredations of the "Alabama?" I believe the damages paid for the "Alabama" were \$15,000,000.

MR. WM. B. COWLES.—It is true that the "Alabama" and "Shenandoah" chased far more American ships from beneath the stars and stripes than they actually destroyed. Undoubtedly the award did not cover everything. It was made as fair as possible, but it could not cover the losses to the American merchant marine which were engendered by fear. Hundreds of American vessels were compelled to change flag in order to make sure of safety on the high seas.

There is one very good reason why the American merchant marine has never recovered its prestige. We were too busy developing our inland resources, in railroading and in following up what the railroads brought to us, to turn our thoughts to the sea. The conditions are now different. The year 1898 has drawn our attention to the sea, and I believe we shall keep our attention there. This is a new era. This country is going to have a navy and

merchant marine, and we are going to carry our own commerce before long. Park Benjamin objects to the bill because there is nothing like it as yet in the foreign navies. He asks, Why should we make such a change? Simply because it is fitting for us to take the lead in any necessary project involving mechanism, this country being a leader of the world in such matters. Let us look at the other extreme. Spain has a good navy; its guns, in some respects, were better than ours. It has brave officers. The year 1898 proved again that the Spaniard is no coward. But he had a modern tool and he did not know how to handle it. The Spanish Navy has no adequate engineer corps. The engineers were hired men of other nationalities.

This is a live subject in every navy, and especially in that of Great Britain. I believe that this Personnel Bill becoming a law in the United States will help on something similar in the Royal Navy.

The point is that the engineer should have an official position such as his duties, his standing, his education and his training warrant. An engineer fights and commands on board ship just as much as a division officer or the officer behind the gun; everything is done by machinery; even the navigation of the ship is engineering.

Our line and engineer officers have been educated in the same school, side by side, under the same instructors. They are brothers until they graduate, and then the service, in some practical respects, puts them at swords points. The line officer has had most of the theoretical education in engineering, but has not had the practice, and the engineer has had nearly all the theoretical instruction of the line officer, but not the practical training and experience in handling ships and guns. The new bill provides that examinations and some experience be required in each branch for the proposed amalgamation. If the older engineer officers do not desire to take these examinations they need not do so, but can continue doing the same engineering duty until they have served thirty years (most have done this already), then they can go upon the retired list on three-fourths sea pay. Thus one who does not choose to take the examinations, or who feels that he has a "grievance," may retire honorably and take his "grievance" with him out of the active list. Such honorable retirement is certainly a full offset for any possible "grievance" any individual may feel; in fact, there are now many of the older officers in the grade of lieutenant who are looking forward to this as a boon, and will gladly avail themselves of the privilege, giving place to younger men. Homo-

geneity is the main object sought, and the country will get this great benefit cheaply and justly by the bill.

Yesterday the Cleveland Chamber of Commerce took action upon this bill similar to that which our Executive Board has taken. I would like to see the members of this Club do everything they can to assist in the passage of this bill, and I do not think it would be out of place for some one to propose an informal vote indorsing the action of the Executive Board.

THE CHAIR.—It would be quite proper for the Club to indorse the action which the Board has already taken.

MR. A. L. HYDE.—I move that this meeting indorse the action of the Executive Board in the matter of the Personnel Bill now pending. Seconded by Mr. Oldham. This was unanimously carried.

CAPT. J. A. HOLMES (visitor).—I am heartily in favor of the passage of this bill. I am pleased to see that the feeling of jealousy which formerly existed is being rapidly outgrown. It has been my endeavor ever since I have been Master to bring about harmonious co-operation. I hope this bill will go through. I think it will wipe out the ill feeling which has existed.

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THE EFFICIENCY OF THE BICYCLE.

BY ROBERT H. FERNALD, M.E., MEMBER, CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read before the Club, February 14, 1899.*]

THE object of this paper is to call attention to a few interesting points in connection with the efficiency of the bicycle.

While it has been impossible for the writer to make any extended investigation in the time at his command, yet enough has been done to start the work along this line at the Case School of Applied Science, where no doubt more extended work will be carried on in the near future.

In the present investigation no attempt has been made to treat the bicycle under road conditions, but simply as a machine; and the efficiency tests therefore have been conducted along the same lines and with practically the same apparatus as that used by Mr. Mack, and described in his paper before the American Society of Mechanical Engineers.

The apparatus, as shown by the photograph, consists of a 10-inch I beam, 15 feet long, planed smooth on top, mounted at a convenient height and carefully leveled.

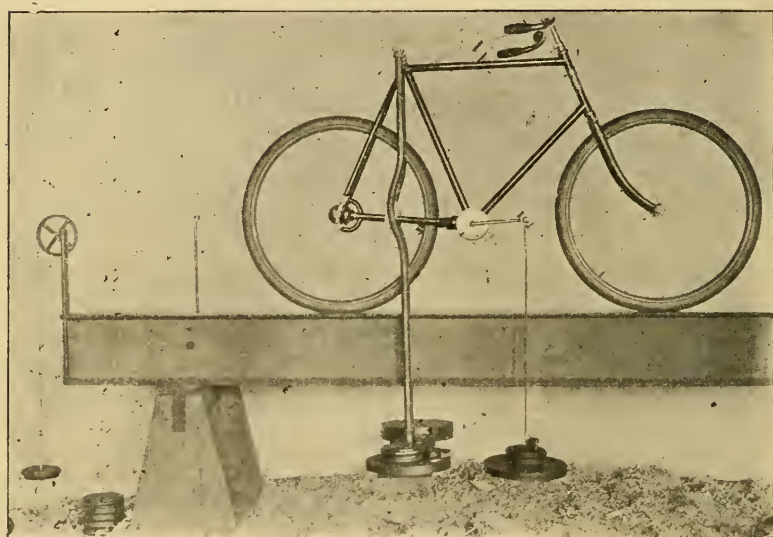
At one end of the beam is fixed a pulley, over which runs a piece of indicator cord carrying a scale pan and attached by wires to the rear axle of the wheel. Suspended from the seat post is a frame made of ordinary inch pipe, and carrying a shelf 3 feet long. This shelf is placed a sufficient distance below the beam to insure

*Manuscript received March 11, 1899.—Secretary, Ass'n of Eng. Socs.

the perfect balance of the wheel when a load of 150 pounds (representing the weight of the average rider) is placed upon it.

The front wheel is maintained in the plane of the rear wheel by means of cords connecting the handle bars to the frame of the machine.

The bicycle is now used as a hoisting machine, known weights placed in the scale pan at the rear of the machine being raised by placing other weights in the pan attached to the pedal. These latter weights, which drive the wheel forward through a short distance, are taken from the shelf, thus keeping the total load on the wheel constant. As weights are transferred to the pedal pan



the balance of the wheel is maintained by adjusting the remaining weights on the shelf.

As the effective radius of the crank varies very slightly for a distance of some ten degrees on each side of the horizontal, it may be assumed as practically constant during this portion of a rotation.

The apparatus thus represents a rider, weighing 150 pounds, sitting upright and gradually throwing his weight from the seat to the pedal, in order to propel the machine.

The circumference of the tire, which enters into the computations, is found by rolling the wheel, with its 150 pounds weight, along the beam, the distance being determined by a mark on the tire.

The efficiency of the pulley must be determined, and the proper corrections made in the indicated weights lifted.

The total efficiency of the wheel is now determined by ascertaining the energy expended in one revolution of the pedal and the corresponding work done in lifting the weight drawn over the pulley at the rear. The difference between the two must be due to the friction of the intervening parts of the machine.

If B equals the circumference described by the center of the pedal pin and P equals weight on the pedal, then $B P$ equals the energy in inch-pounds expended in one rotation of the pedal pin.

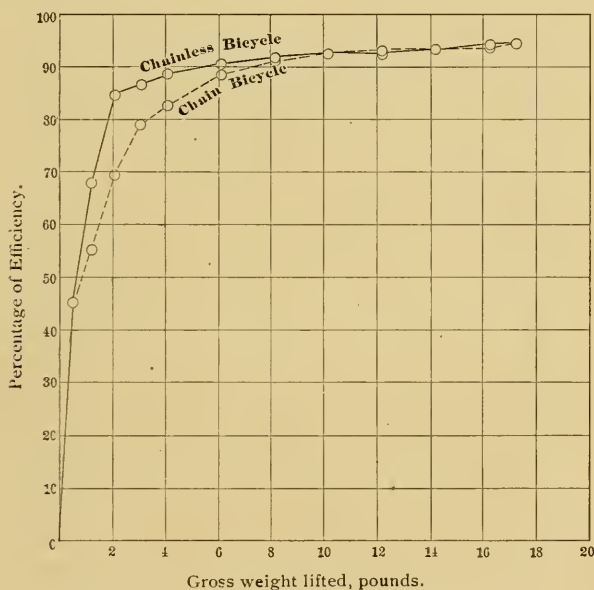


FIG. 1. CHAIN AND CHAINLESS BICYCLES.

If R equals ratio of large to small sprocket and A equals circumference of tire, then $R A$ equals distance passed through by the machine for one revolution of the pedal pin.

Letting M equal the resistance overcome, which would equal the weight placed on the pan at the rear of the machine, divided by the efficiency of the pulley, then $M R A$ would equal the actual work accomplished.

The efficiency would then be determined by the fraction $\frac{M R A}{B P}$

It may be interesting to note that it was the belief of the writer that the value of R could not be obtained accurately by the simple method of counting the number of teeth on the two sprocket wheels when the teeth outlines were nearly straight as is the case

with many sprockets, but *only* in the cases where the teeth were constructed according to theoretical principles. After many careful measurements it was found that in every case the correct value of R was given by the simple ratio of the numbers of teeth.

In the accompanying diagrams the curves are so plotted that the ordinates represent the percentage of efficiency, and the abscissas the gross weight lifted at the corresponding efficiency.

One of the first points of interest to be noted is the relative efficiency of the chainless and the chain wheels.

The number of tests made has been too small to determine definitely the relative efficiency of the two makes under the same

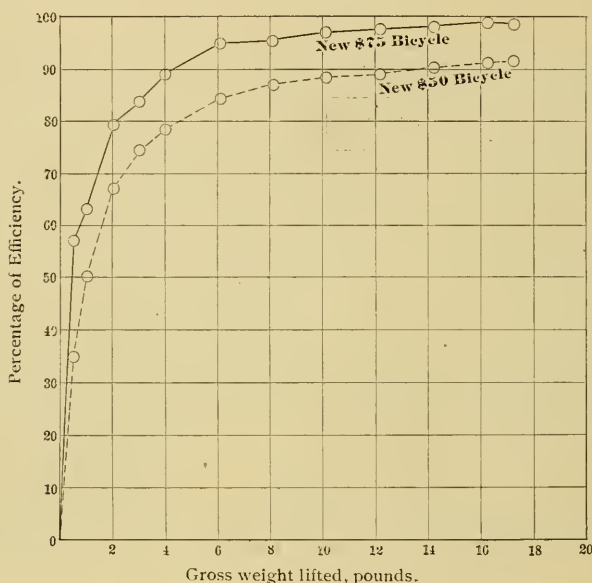


FIG. 2. HIGH-GRADE AND MEDIUM-GRADE BICYCLES.

conditions. It was found difficult to procure exactly the same conditions regarding gear, tires, etc.

Fig. 1 shows the results obtained from two wheels of the same make and grade, these particular curves being chosen as they give practically the same maximum efficiencies.

The full line is the efficiency curve of the chainless wheel, and the broken line of the corresponding chain wheel.

While the maximum efficiencies are practically the same, it will be noticed that the chainless shows a higher efficiency for the smaller loads, which was found to be generally true.

Fig. 2 represents the relative efficiencies of the two grades of wheels turned out by the same company. The two wheels were

obtained directly from the factory, and they represent the work of one of the leading bicycle firms. Both wheels were in the best possible condition. Their relative values were \$75 and \$50.

Fig. 3 shows some very interesting facts. The upper, or full line, curve shows the results obtained from a special racing wheel, gotten out for the use of a man riding for the company. It was understood that the bearings were specially ground, and everything done to make the wheel represent the best possible conditions. It was very light in construction, and carried $1\frac{3}{8}$ -inch tires. The wheel had been ridden only a few hundred miles, and before being tested was specially cleaned and oiled.

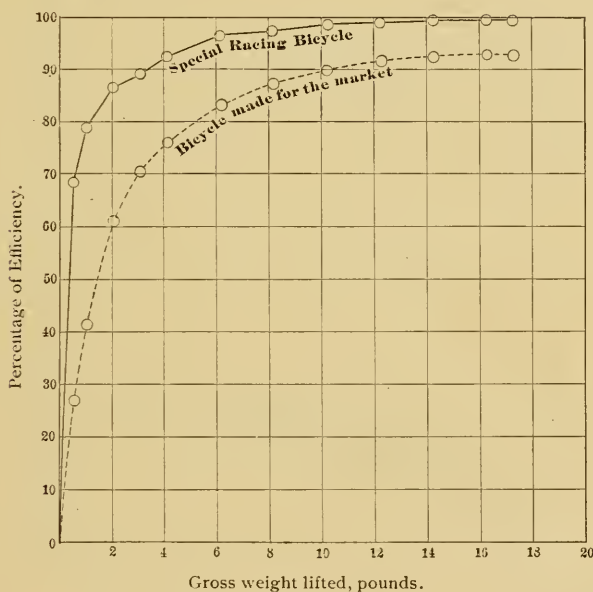


FIG. 3. SPECIAL AND COMMON BICYCLES.

The second, or broken, curve represents the wheel manufactured by the same company for the use of the general public.

Fig. 4 shows the results of tests upon two comparatively cheap wheels. The upper curve represents a wheel of medium grade, and the lower a cheaper wheel, retailing for \$25. Both wheels show remarkably high efficiencies.

Fig. 5 represents the results of careful cleaning. The broken curve shows the effect of general neglect, the chain being slightly coated with mud; and the full curve represents the same wheel after thorough cleaning.

In Fig. 6 the broken curve was obtained from a wheel of high grade taken direct from the factory. In this particular wheel the

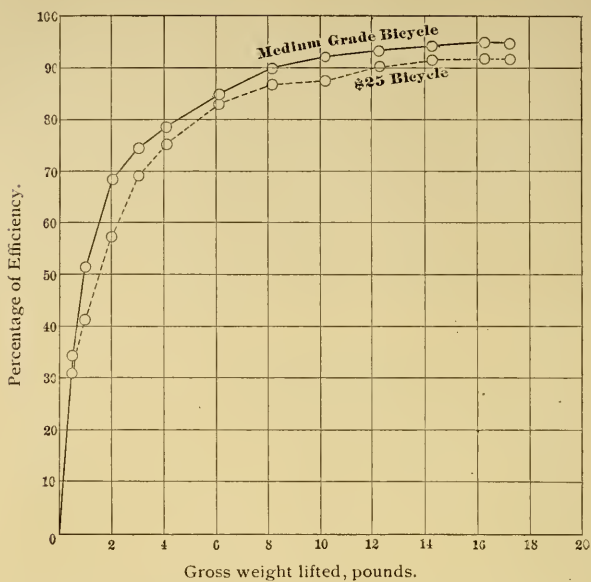


FIG. 4. MEDIUM-GRADE AND CHEAP BICYCLES.

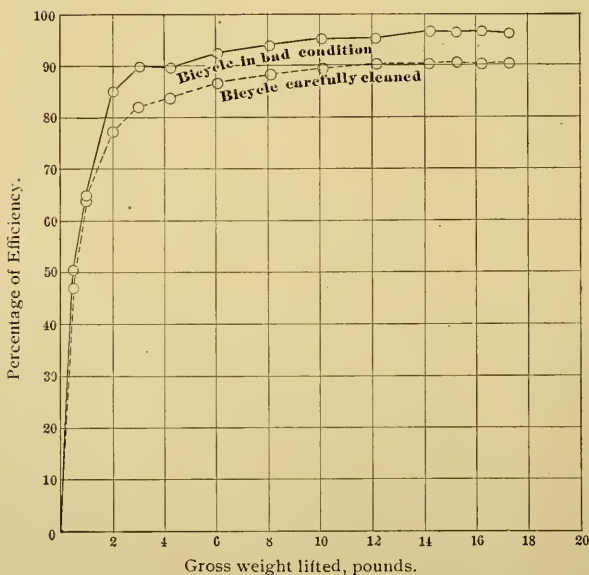


FIG. 5. BICYCLES IN GOOD AND IN BAD CONDITION.

In Fig. 5 the titles of the two curves have been reversed by mistake. The upper line should read "Bicycle carefully cleaned." The lower line should read "Bicycle in bad condition."

sprocket wheels and chain were apparently rough in finish, and gave a very irregular efficiency, which was far from satisfactory. After having the wheel ridden a few hundred miles it was again placed upon the testing machine, and showed what was expected, the smoothness of action and higher efficiency shown by the full curve.

In Fig. 7 is shown the general effect of oiling a chainless wheel. The broken-line curve was obtained from a chainless wheel that had been ridden for weeks by every one that happened to so desire. The gears had been packed with asbestos paste. At the suggestion of the writer the wheel was taken apart, and it was

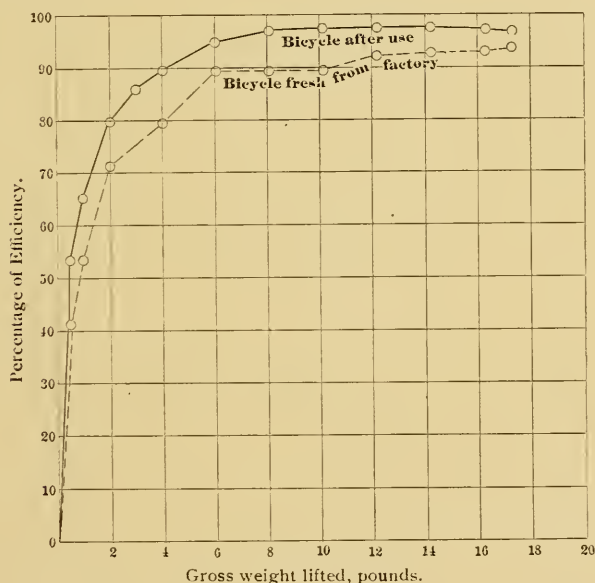


FIG. 6. NEW AND USED BICYCLES.

found, as had been expected, that the paste had been squeezed from between the gears and the cogs were running dry. The wheel was then thoroughly oiled with heavy cylinder oil and again tested, with the results shown by the full-line curve.

Fig. 8 shows a wheel representing the best practice in bicycle construction and method of protecting bearings, after continued exposure to rain. The wheel was frequently left lying out in the rain for hours, and received no care. The curve shows a remarkable efficiency, and, while the average is far lower than that of the corresponding wheel in good condition, yet it would indicate that the bearings had been but little affected by such usage. The chain,

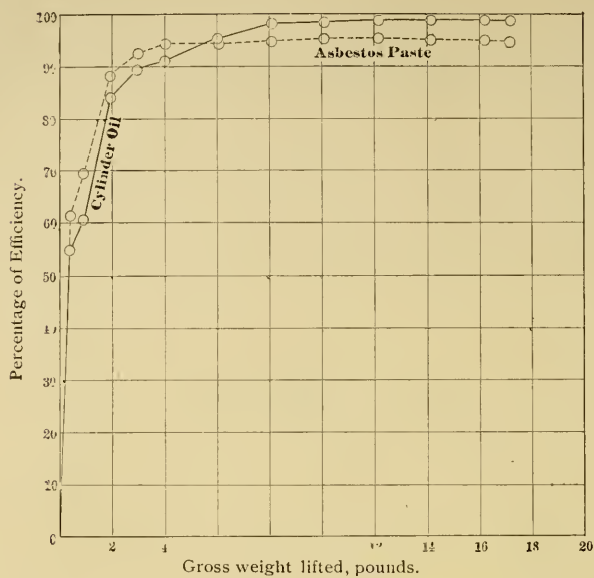


FIG. 7. EFFECT OF OILING ON CHAINLESS BICYCLE.

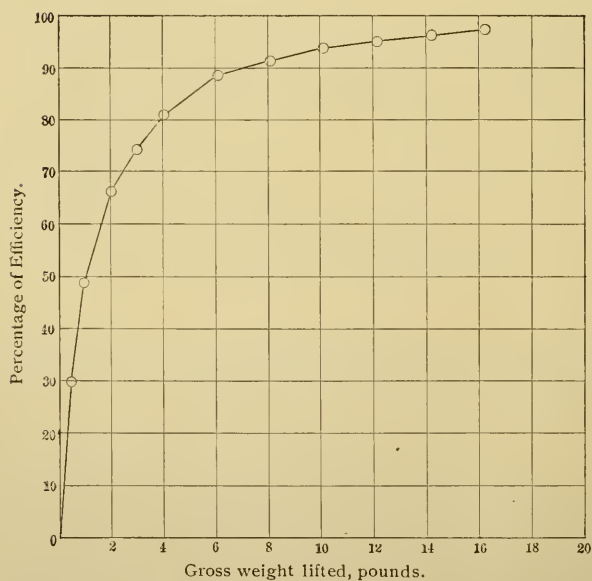


FIG. 8. CHAIN BICYCLE, WITH PROTECTED BEARINGS, AFTER EXPOSURE.

while slightly rusted, was entirely free from mud or dirt, which undoubtedly accounts in part for the remarkable showing.

Besides the tests on general efficiency, a few special tests have been made. Among the results of greatest interest are those obtained from the sprocket tests.

A wheel, very kindly loaned by one of the leading bicycle firms, was carefully kept under constant conditions, with the exception of the change of sprocket wheels. All the combinations obtainable with eight, nine and ten-tooth rear sprockets and from twenty to twenty-five teeth, inclusive, on the front sprocket were tested.

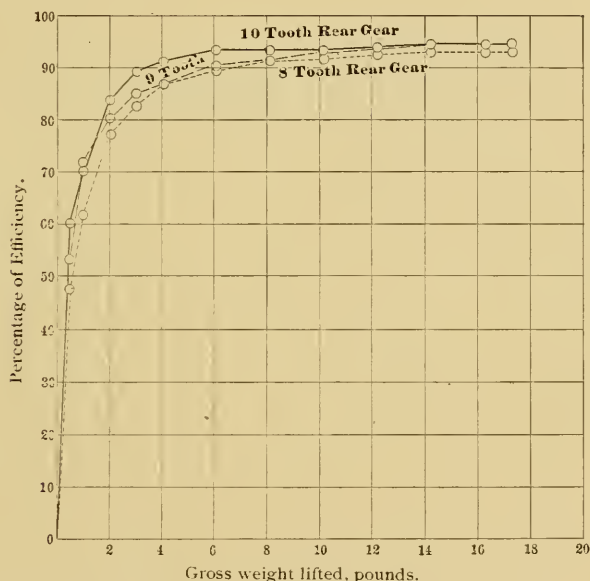


FIG. 9. 20-TOOTH FRONT GEAR, WITH 8, 9 AND 10-TOOTH REAR GEAR.

Fig. 9 shows the results obtained from one such combination, being in this instance the twenty-tooth front with the eight, nine and ten rear. The dotted curve represents the efficiency resulting with an eight-tooth rear. The broken line represents that obtained with the nine-tooth rear, and the full line the corresponding efficiency for the ten-tooth rear.

Fig. 10 gives the average results of the preceding combinations. The dotted curve is the average of the tests with the eight-tooth rear and the six different front sprockets. The broken line is the average of the nine-tooth rear under the same conditions, and the full line that of the ten-tooth rear. While a slight irregularity seems to exist for the smaller loads, the effect for the higher

pressures is very apparent, and shows for the average maximum values that the nine-tooth rear has an efficiency equal to 98.7 per cent. of that of the ten-tooth, and the eight-tooth an efficiency of 98.6 per cent. of that of the nine-tooth. The eight-tooth would then show an efficiency of 97.5 per cent. of that of the ten-tooth.

It has been often asserted that the tire is the most important factor affecting the efficiency of a wheel, and that the amount of inflation would hide all other possible chances for variation in efficiency. While no attempt has been made in these tests to go into this question in detail, yet just at the close of the other experiments a few interesting results were obtained along this line, Fig. 11.

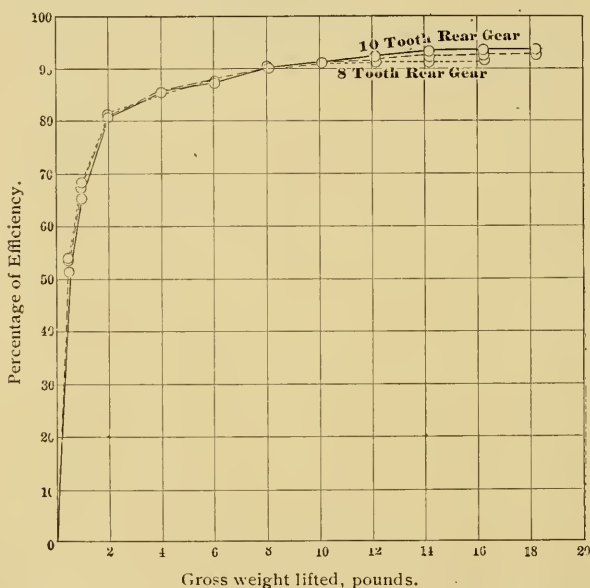


FIG. 10. AVERAGES FOR 8, 9 AND 10-TOOTH REAR GEARS.

All conditions of the wheel were maintained the same, with the exception of the rear tire. In the first experiment the circumference of the rear tire was held at 85 inches under the 150-pound load, this being the same circumference that had been used for all the sprocket tests.

The upper or full-line curve gives the resulting efficiency. The air was then allowed to escape till the tire had a circumference of 84 inches, under the same load, and the curve shown by the broken line resulted. Again the circumference was reduced to 82.5 inches, or until the wheel was nearly running on the rim, giving results as shown by the dotted curve.

The results given in this paper are necessarily very meager, but they give an idea of the many points of interest to be investigated in this comparatively new field. While these experiments have been based on the bicycle used purely as a machine, such results would prove far more interesting and of more general value if actual road conditions were approximated. Such attempts have already been undertaken by one or two bicycle companies and by one or two institutions, and it is hoped that such work may soon be carried on at the Case School of Applied Science.

It is the present intention to make tests with wheels running at different speeds, and also when the wheels are forced to run over

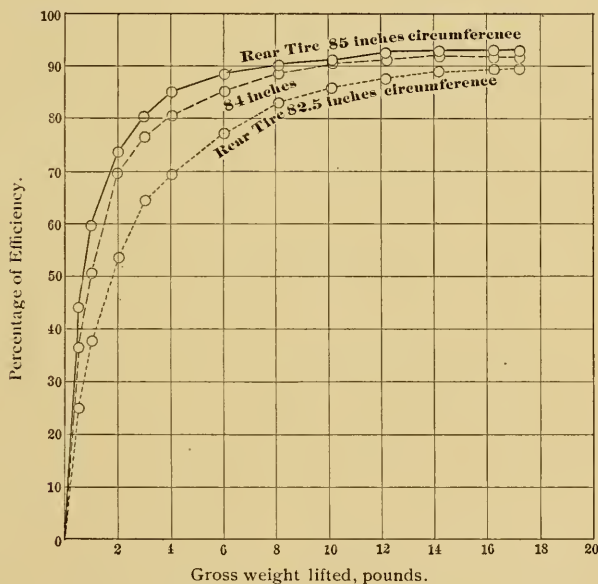


FIG. 11. EFFECT OF INFLATION OF REAR TIRE.

different obstructions made to represent road conditions as nearly as possible, the power required to drive the wheel being determined by a dynamometer.

It is also probable that a pedal dynamometer will be constructed to register the actual force exerted on the pedal by the rider when the wheel is in regular road service. There are many other points of interest, among which are the duration of cone and ball bearings, the effect of vibration of the frame and the efficiency of different makes and grades of tires under increase of speed.

These different points will be investigated as time permits, and a series of results obtained which will be far more complete than those presented in this paper.

DISCUSSION.

DR. J. W. LANGLEY.—What weight is represented by the abscissæ 2 and 4.

PROFESSOR FERNALD.—The abscissæ correspond with the weights that are suspended over the pulley at the rear of the wheel. It has been estimated that a weight of 15 pounds suspended at the pulley is equivalent to the resistance of a grade of 1 foot in 12. The heavier the load that the bicycle has to lift the more pressure it requires to drive the pedal.

PROF. C. H. BENJAMIN.—I have watched these experiments with interest. The efficiency of nearly all machines increases as the load increases. This is especially true of the steam engine. The friction is practically constant, and when the engine is simply running itself the efficiency is zero. This is not true of the bicycle to the same extent, but it is approximately true. The speaker has shown that tests of this character are purely relative, but they illustrate the value of the bicycle as a machine. No matter whether this percentage is the actual efficiency on the road or not, it shows the relative value of the wheels as they are made. Relative to testing wheels under road conditions, the method by which we intend to do this next year is to mount the wheels on rollers, one roller under each wheel, and have a man get on the wheel and ride it. The wheel will be fastened by a cord running back from the rear wheel, and that will be attached to a spring balance which will give the pull of the wheel. He can ride fast or slow, and will get the same effect as traveling on the road, excepting that he will get no further. The power will be absorbed by brakes on the large rollers, which represent the track. The shape of the rollers can be changed to represent different conditions of road. Professor Fernald suggested the idea of putting a dynamometer under the foot of the rider. I think that could be done. The experiments can be made to approximate road service more nearly, but I think the relative values will be just the same as shown in these tests.

MR. S. T. DODD.—Professor Fernald was speaking of the proportion of the weight on the pedal to the weight lifted. If 17 pounds lifted corresponds to 75 pounds on the pedal, what weight on the pedal would 1 pound lifted correspond to? About how much weight is there on the pedal for 1 pound lift?

PROFESSOR FERNALD.—Approximately 5 pounds; from 2 to 5 pounds, depending upon the wheel and the gear.

MR. S. T. DODD.—About how much pressure is generally put on the pedal under ordinary conditions on a level road?

PROFESSOR FERNALD.—I have no idea. In riding up hill a

man puts more than his whole weight on the pedal, but I do not know what would be the conditions on level road. I suppose he would put from 2 to 5 pounds on the pedal.

PROFESSOR BENJAMIN.—When a man is putting 5 pounds pressure on the pedal, as on a level road, he does not care much about efficiency, but when he gets up to his full weight he begins to worry about the efficiency.

EXPERIENCE IN SEWER CONSTRUCTION.

BY L. M. HASTINGS, MEMBER, BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, January 25, 1899.*]

OF the several elements which determine the size, character and cost of a sewer system for any community, perhaps the most important is the natural conditions which obtain in the locality to be sewered. The natural conditions here referred to are the slope or inclination of the surface and the character and condition of the soil. The first, by influencing the amount of storm water to be received in a given time, the rapidity with which that and sewage may be removed and the depths at which the sewers are to be placed, is a large factor in determining the sizes required. Much study has been devoted to this matter, and the effect of inclination or slope has been fairly well determined.

The second, as related to the difficulty of excavating and maintaining trenches, in requiring the removal of more or less rock or water, and expensive bracing or special foundations, very directly affects the cost of the work, and varies greatly with the locality. The value of this element is often very difficult to determine. Both these elements should be carefully studied in preparing a scheme of sewers for any district.

It is proposed in this paper to note some experience gained in the city of Cambridge, as bearing on the second element mentioned. The sewers are constructed on the combined system, the diameters varying from 8 inches to 8 feet 4 inches. In constructing the sewers nearly every variety of soil may be encountered, except ledge, which is found only at considerable depths below the surface. The city may be roughly classed in three divisions or zones, as regards the character of soil.

First. The hills and highest lands, which are largely of clay foundation.

Second. The plains and lower land, which are of sand or gravel, usually of a very superior quality, seemingly drift or glacial deposit.

Third. Marsh land and flats adjoining the rivers, and lying at an elevation about equal to that of high tide in the harbor. It may be remarked that the portions classed under the second and third divisions are often underlaid with clay at no great depth from the surface. At the line where the upland and marsh come together

* Manuscript received January 14, 1899.—Secretary, Ass'n of Eng. Socs.

large quantities of water are always found, and as well on the clay, after passing through the overlying sand in deep trenching.

The total area of the city, not including the parks, is 3864.2 acres. Of this, 1206.5 acres are more than 15 feet above mean high tide, 1012.4 acres are between 5 and 15 feet above mean high tide and 1645.3 acres, or about 43 per cent. of the whole area, are less than 5 feet above mean high tide. These divisions or zones would roughly correspond to the classification already made as to soil.

The construction of sewers in the first zone is attended with no special difficulties, the soil being usually firm and hard, with little water; and the sizes of sewers required are small. In constructing these sewers, especially those made of pipe, it has been necessary to be particularly careful in bedding the pipe and in the back filling. The hard material must be removed from the side and bottom, for a space about 6 inches larger than the outside of the pipe, and replaced with sand or gravel, not too coarse, and covering the pipe at least 6 inches above the top. In ledge work the same course should be pursued. This treatment is usually sufficient to keep the pipe from fracture. If the material is very hard and difficult to replace, or soft and liable to unequal settlement, it will be better to bed the pipe solid in concrete.

From 1871 to 1876 large quantities of cement sewer pipe were laid by Cambridge, mostly in this zone, and without special care as to bedding the pipe in gravel, etc., the work being done by contract. Numerous failures of the pipe resulted, due partly to the inferior quality of pipe used and partly to the method of laying.

All pipe now used in this city is of the "Standard Akron" or "Portland Stone Ware Company" make, subject to the usual inspection, and usually of standard thickness. Practically all the sewer work in Cambridge is done by day labor.

A limited amount of "double strength" pipe has been used, but my experience here would seem to indicate that in situations where the best standard pipe will fail the double strength would often prove deficient; and so the standard pipe, reinforced with concrete or brick, has been adopted. Unskillful work in bedding and packing the pipe, not keeping the sheeting drawn in advance of the refilling, and unequal ramming are common causes of a provoking failure in otherwise good conditions. The work of the steam road roller as an engine of destruction must also be considered in some conditions.

The difficulties encountered in constructing sewers in the second, or middle zone, are much greater than those found in the first. The soil is loose and porous, and frequently large quantities

of water are encountered. The sizes of sewers required are also larger for this zone, rendering the general cost much greater.

For sewers having sizes above 18 inches the materials mostly used are brick and concrete. In the early days a favorite form was the "half-barrel," with a circular invert, straight sides and covered with flat stones from a slate-stone quarry. A curious fact noticed about this form is that the bottom courses were laid without cement, and that the slate-stone covers have shown in many cases evidence of deterioration, a species of rot or softening of the stone making it liable to break and fall in.

Where the material is suitable, one of the most satisfactory combinations of materials has been found to be a concrete invert with brick arch. Three samples of this type are shown in Figs. 5, 8 and 14.

The concrete in the invert of Fig. 5 is made of Hoffman cement one part, sand two parts, screened gravel four parts, the sand and gravel, of excellent quality, being found in excavation. The trench was dug to the form required for the invert; the forms were covered with zinc and well greased, and, after the forms were set, the concrete was rammed in a plastic condition in place. After a proper time the forms were taken out, and the inside then finished with two coats of Portland cement wash. This sewer was 13 feet deep, and cost \$3.22 per foot, including slants, manholes, etc.

The sewer shown in Fig. 8 was in shallow digging with soft material, requiring a platform and the side sheeting to be left in place. After the invert forms were drawn a $\frac{1}{2}$ -inch plaster coat of Portland cement and sand was smoothly troweled on. The section shown in Fig. 14 was built as a storm water overflow, in much the same way, except for the platform. The depth varied from 11 to 18.50 feet. The average cost, with all appurtenances, was \$5.60 per foot. The ease with which the bottom is placed, the greater smoothness and symmetry of the section and the greater economy obtained with this method of construction recommend it very strongly.

By far the greatest difficulties in sewer construction are found in the third or lower zone. Of the 1645.3 acres contained in it, the larger portion are flats, either fresh, as at the Fresh Pond Meadows, or salt marsh, bordering the Charles River. This marsh is composed of a layer of salt much resembling peat, varying from 8 to 20 feet in thickness, resting on a bed of clay or gravel. All this muck is soft, and possesses little carrying power, its chief characteristic being a persistent tendency to yield or settle when loaded. Large tracts of this marsh have been reclaimed, from 3 to

6 feet of filling put on it and houses and streets built. The moment it is filled settlement begins, and a curious thing about it is the length of time during which it continues, especially if new filling be added. A very common amount of settlement is 2 to 3 feet. One street, built on a marsh of this character, and carrying a street railway track, settled for at least fifteen years, necessitating raising the track several times and putting on about 3 feet of additional filling; and it is now below grade. It will be seen that with these conditions the problem of stable and permanent sewer construction is a difficult and expensive one.

As the sizes in this zone vary from the smallest in side streets, or laterals, to the largest in the main or trunk lines, a great variety of design must be adopted. A greater part of the sewers must be carried on a pile foundation. This at once introduces a new element of danger; for the material at the sides is soft and possesses little resistance, and, the bottom being on a firm, unyielding base, the tendency to failure from loading the top is greatly increased.

Pipe sewers, unless heavily reinforced, have repeatedly failed. Fig. 1a shows a 10-inch pipe so laid some years ago. This was found cracked and broken from settlement of the material. It was relaid as shown in Fig. 1. Ten-inch ring pipe was used, bedded in concrete, and a brick arch turned over it. Fig. 2a shows a sewer which stood for some years. The street was resurfaced and rolled with a steam roller. In a short time a stoppage was reported, and the entire length of sewer was found crushed. It was rebuilt as shown in Fig. 2, with 15-inch ring pipe laid in a wooden cradle with a brick arch. Fig. 3a shows the construction of an 18-inch sewer. This was built before the street was fully filled. The filling, which was excellent material, was carefully placed, so as not to disturb the pipe. The street was afterward paved with Telford pavement and rolled with a steam roller. After a few years this too was found collapsed and broken, and also some 15, 12 and 10-inch in the same street. This was rebuilt on the same foundation as shown in Fig. 3.

In one case a sewer was put in a street which, while originally soft, had been filled and traveled over for some years. Part of the sewer was on piles of form similar to Fig. 2a. After the sewer was constructed more filling was put on the street. The result was fractured pipe and a clogging of the sewer. It was rebuilt as shown in Fig. 10.

Figs. 6 and 7 show sections where great stability seemed necessary, and where a double line of piles was driven, not opposite each other, but "staggered" like rivets

In pile foundations it is best not to place long stringers on the heads of piles, owing to the difficulty of driving them in line and cutting them to grade. Much better work can be done by using cross-caps spanning two piles. These caps should be of hard pine, as the softer woods are sometimes injured by the great pressure on the heads of the supporting piles.

In Fig. 6 a heavy 4-inch platform was laid on the caps, making a shallow foundation, and so avoiding about 10 inches of wet digging, as necessitated by Fig. 7. In this, however, opportunity was given to use up old 2-inch and 6-inch stock on hand.

The section shown in Figs. 9, 11 and 12 have the same general features for foundation, but with brick construction.

The sewer shown in Section 13 was built under somewhat peculiar conditions. While the locality was some distance from the Charles River, the filling material used in making the land was unusually coarse, mostly oyster shells. Through this the water rose and fell with the tide. To pump it out was expensive, and to stop it almost impossible. Three x 8-inch spruce stock was milled to the exact bevel required, and as many were spiked together as would make a section as large as could be handled on the bank of the trench. After the piles were driven, the girder caps bolted and cradles fitted, this section was easily landed in the trench, and rapidly built up by spiking additional strips in place; any slight deviation from the form being corrected by thin wedges placed at the front or back of the strips. This sewer was built in 1882, and is now perfectly sound, as shown by a recent examination.

Fig. 16 shows a combination of separate sewers and storm water drain, laid in the same trench and carried by the same foundation. The material is 5 to 6 feet of filling, and about 12 feet of mud and a sand or clay bottom. The trench is first dug, piles driven and the underdrain laid. The piles are then cut and capped and the platform laid. The separate sewer is then laid in and covered over with concrete. Branches are put in every 30 feet and carried to the sheeting, which, of course, is left in place, being cut above the top of storm drain. The plank at the end of the branch is partly drawn, so that it may readily be connected later to the house drain. The trench is then filled to the grade of the bottom of the storm water drain with gravel well compacted. Upon this the concrete and brick drain is built as shown. Slants are inserted at intervals of 30 feet, as in the separate sewer also.

The proper construction of tide outlets is one which requires some care, simple as they usually are. Extending from the tide gates to open water at the discharging points, and subject to the

action of salt water and ice, they are usually built of wood and held in position by piles. It is sometimes as necessary to keep the outlet down—*i.e.*, from being lifted or moved by ice outside—as it ordinarily is to hold a sewer up and prevent its settlement. Fig. 15 shows the common construction of a small wooden outlet. The 6 x 10-inch sills rest on girder caps bolted in pairs to the piles. As the mud settles and the spikes by which the bottom planks are attached to the sides rust off, unless carried by the sills, the bottom plank in time falls away from the sides. Unless held by the top girders or heavy filling, the box tends to rise at high water. When the sewer is of large size, say 3 feet 6 inches x 3 feet 6 inches and over, the side walls should be stiffened with oak posts about 3 x 5 inches, placed inside the box and notched into the top and bottom plank, spaced about 3 feet 6 inches apart. The side timbers are pinned with tree nails every 2 feet 6 inches. The cross-girders should be notched into the piles, so that, after the bolts rust out, a bearing will still be had on the wood. Unless placed too high, these wooden outlets are very durable. A number of them, in the city, have been built forty to fifty years, alternately exposed to air and water, and are now in good condition.

In sewers which drain low territories, subject to the action of tidewater, automatic tide gates, designed to keep back the water when the tide is high, and allowing the sewage to discharge freely when the tide is low, are an important adjunct.

The gates must fit tightly when closed, especially if the sewers are connected with the Metropolitan Sewerage System, as most in this vicinity are; must be simple in construction and sensitive in action, so as to open freely and not obstruct unduly the flow through them when open.

Many forms of gates and chambers have been devised in England and in this country. For large sewers I doubt whether anything superior to the old-fashioned "barn door" gate, shown on the plate, has been devised. If made of good material, well fitted and hung with composition metal hinges, it is easily operated and kept in order. The construction is clearly shown in the plate. For smaller and medium-sized sewers the most satisfactory gate I have ever tried is shown in the second plate. This is modelled after a gate used in Providence, R. I. The frame of the gate is made of cast iron, with six lugs cast in the back to extend into the masonry and hold it firmly in position. The face of the frame is planed to a true surface, to which the gate is fitted. A 3 x 3-inch heavy angle iron is then bent in the form of a hoop of the exact size of the gate. In the inside of this hoop the wood is fitted. This is made

of $\frac{7}{8}$ to $1\frac{1}{4}$ -inch cypress, in two thicknesses, the thickness varying with the size of the gate. The two courses cross each other at right angles, and are fastened with brass screws. To keep the wood straight and prevent swelling it is first soaked two or three days in water, and fitted in that condition. After the gate is made, the rim is then planed to fit the cast iron frame. The hinge lugs are then bolted in place and the gate hung. In smaller gates the iron hoop is dispensed with, and a rubber gasket nailed to the face of the wooden gate. The long link hinges make them very easy to operate for a suspended gate. The link is made of wrought iron, with composition metal bearings. To reduce the danger of leakage, by reason of their being held open by obstructions, clogging, etc., in the gates, they are usually built in pairs,—*i.e.*, with two gates in one chamber. A type of small cast iron gate is shown in the last figure. This gate is useful, but is apt to be heavy, and consequently hard to operate. The lid or flap should be cast as thin as practicable, in order to lighten it.

DISCUSSION.

MR. GEORGE A. KIMBALL.—I have been very much interested in Mr. Hastings' paper, in which he has so fully described the methods adopted by him in sewer construction, but there are a few points where the opinions of engineers may differ as to the best practice.

Mr. Hastings stated that it was his custom to build an 18-inch sewer with a concrete invert and brick arch. My experience has led me in a different direction. I have always considered it better to build this sized sewer of pipe reinforced by concrete rather than to use brick and concrete. I think there is some danger in using concrete for the invert of sewers, although I admit that if built of the Portland cement according to the modern methods it is much better than by the old style of construction. I have seen cases in old sewers where the acids which are carried in the sewage have eaten the inverts.

MR. HASTINGS.—Mr. Kimball's points are well taken and important. I think, however, his fears are groundless, for the surface of the sewer I have built with concrete invert has been *very much* smoother than any pipe sewers, principally on account of their being no joints as in pipe sewers. I have never seen a smoother, truer job than was obtained on No. 8 and No. 14. With regard to action of acids on Portland cement, I never yet have seen any such action on the Cambridge sewers, either cement pipe or brick, and some of the cement pipe was pretty poorly made, rendering it peculiarly subject to any such action if there was any.

MR. T. HOWARD BARNES.—I would like to ask Mr. Hastings if he knows of any specific case of failure of pipe due to the action of steam road roller?

MR. HASTINGS.—I can now recall two cases,—one referred to in the paper in speaking of Fig. No. 2 a and No. 2. In this case I lay the trouble entirely to the steam roller. Another case was that of a 24-inch pipe laid in sand about 7 feet deep. The trench was filled up temporarily with the sand and surfaced and rolled with steam roller. On opening the trench to extend the sewer the pipe was found crushed for about 25 feet from the end.

MR. E. S. DORR.—I would like to ask Mr. Hastings in regard to single rows of piles for sewer foundation. I have often, from economical reasons, been tempted to use a single row of piles, but lacked the nerve to do so. I would like to ask Mr. Hastings if he has not had more or less trouble in properly aligning the piles.

Also I wish to ask about the manhole for the double sewer shown on Fig. 16,—how the lower sewer can be reached?

MR. HASTINGS.—I have never found any trouble in driving piles near enough to a line so that foundation can be safely placed on them. The material is usually soft and the trench nearly excavated before the piles are driven, so that there is practically no trouble in getting a good line by using care.

The manhole is a two-story one, the upper part having a false bottom with cast iron frame and plate iron cover in two pieces. This is calked in place when set, and can be easily taken out when an examination of the lower sewer is desired. This, of course, would never happen when any water would be running in the upper sewer, as it is a storm sewer.

MR. ALEXIS H. FRENCH.—I have been a good deal interested in Mr. Hastings' paper, as many of the problems are similar to those we meet in Brookline, where we have numerous areas of vegetable deposits from 10 to 50 feet deep, and the surface of some of them as high as 200 feet above sea level. The streets built over them continue to settle for many years, and it frequently becomes necessary to build sewers in these streets while the settlement is in progress. In the deeper deposits it is the practice to build the sewers on timber platforms supported by piling, making the construction strong enough to carry say 10 to 12 feet in depth of earth and resist the strains produced by the continued settlement of the earth on either side.

The most interesting recent case occurred on Beacon street, where there was formerly a "kettle hole" some 300 feet in diam-

eter, filled with a semi-liquid mud from 40 to 50 feet in depth. When the Beacon street improvement was made, the depression was filled with gravel, which had the effect of displacing the mud. About a year subsequent to the filling, a 40 x 60-inch sewer was laid over this place upon a timber platform supported by piling driven through the filling well into the soil below it. The street continued to settle for several years, carrying with it the sewer and platform, without doing much injury to the former beyond producing a lump in which the road detritus tended to settle and from which it was difficult to remove it. Last summer, the settlement then being about 4 feet, the sewer was reconstructed on the old foundation by building up to the proper height with concrete. The work was done this way partly from motives of economy and partly because it did not seem probable that any foundation could be made which would withstand the further settlement of the gravel filling.

Some years since there came under my observation a case where a 24-inch Akron pipe, about $1\frac{1}{4}$ inches in thickness, was laid on a timber platform and held in place by short timber "chocks," two to each pipe. Most of the pipes were broken into two pieces by longitudinal cracks following the crown and invert.

The pipe was probably too thin, even to be laid in from 8 to 10 feet of sand, but I suspect that the breakage was due to the lack of uniformity in the support furnished by the timber platform and the back filling.

In designing some time since the foundation for a 15-inch pipe sewer, subjected to a light load, piles were driven in pairs at 12 feet intervals, cut off below the water level, cross-capped with hard pine made into the form of skew backs and brick arches thrown from bent to bent; a continuous wall of rubble masonry was built on top of the arches to the sewer grade, the sewer pipe laid and inclosed in brick masonry.

MR. DESMOND FITZGERALD.—As the construction of sewers in abnormal positions is in order, perhaps it may not be uninteresting to the Society to hear about a sewer that I once had occasion to build under one of the main tracks of the Boston and Albany Railroad. It will be remembered that a considerable portion of the tracks between the present station and the Providence Railroad crossing is below high water, and that occasionally the tracks are flooded when a particularly heavy rain occurs at the same time with high water. When I was engineer of the railroad, some twenty-five years or more ago, the tracks were often flooded to a depth of 2 or 3 feet with water, which sometimes stopped the trains.

FIG. 14



FIG. 15



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Fig. 1 a

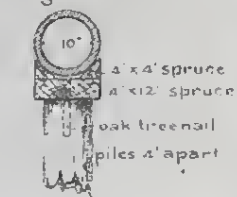


Fig. 1

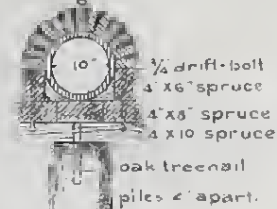


Fig. 4

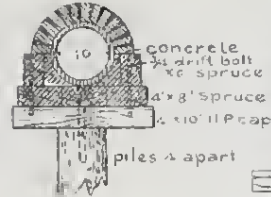


Fig. 7

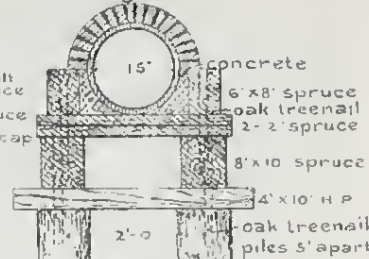


Fig. 10

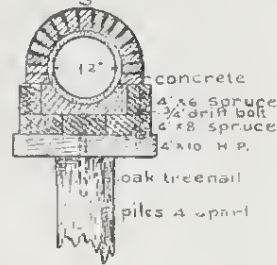


Fig. 12

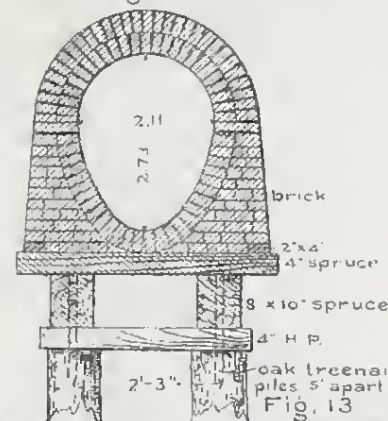


Fig. 14

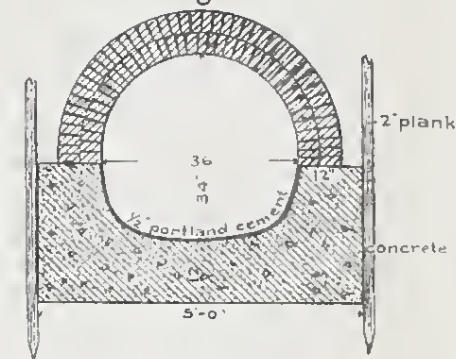


Fig. 16

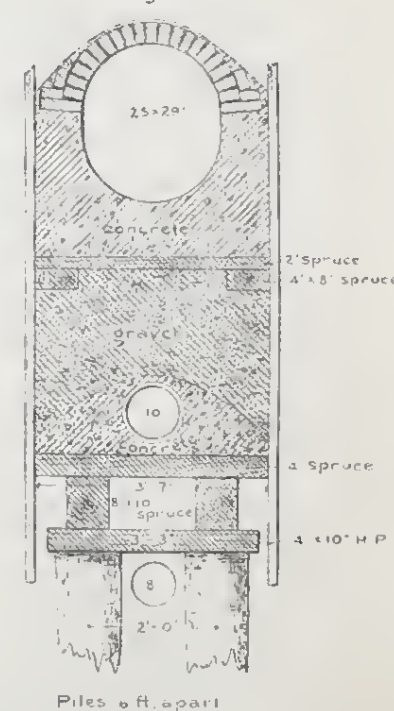


Fig. 2 a

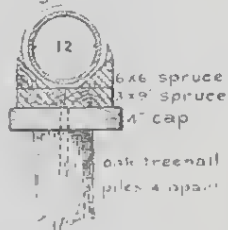


Fig. 2

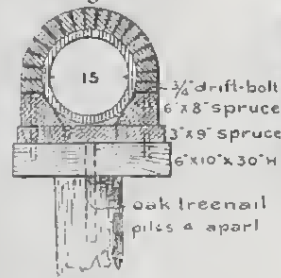


Fig. 5

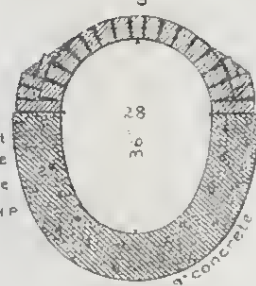


Fig. 8

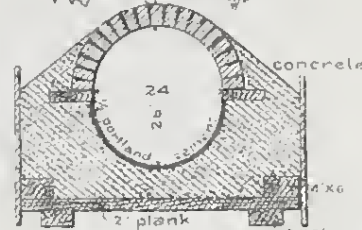


Fig. 11

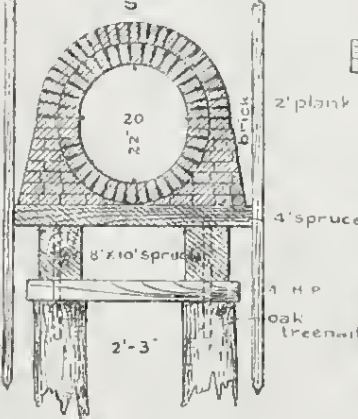


Fig. 9

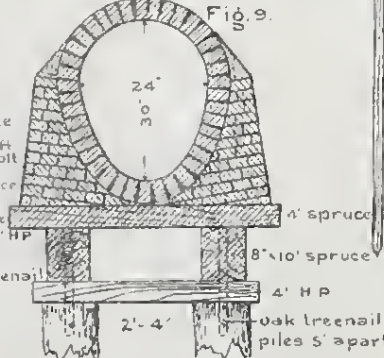


Fig. 6

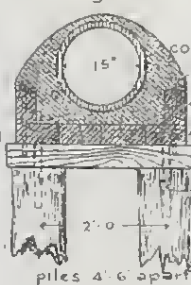


Fig. 3

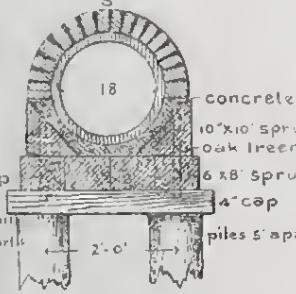


Fig. 3 a

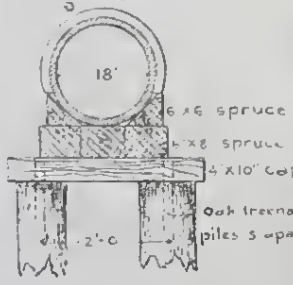
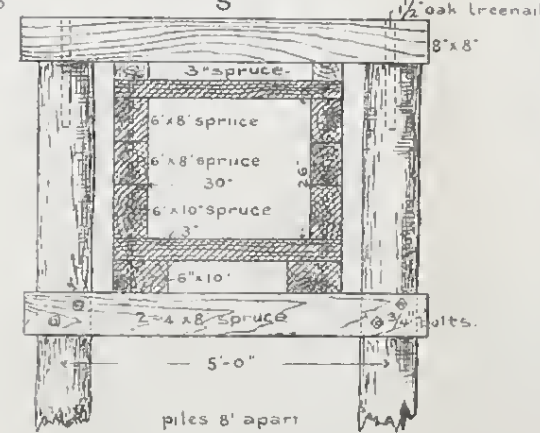
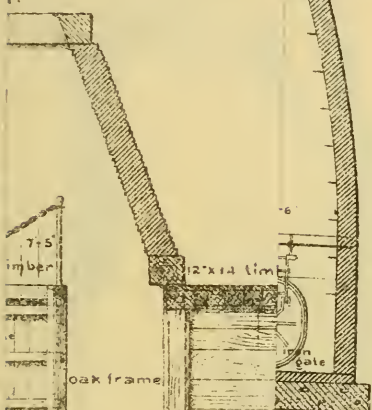


Fig. 15

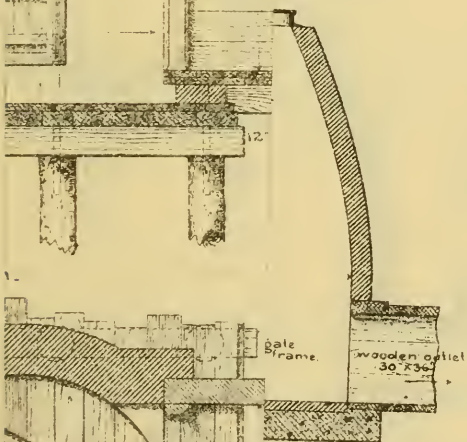


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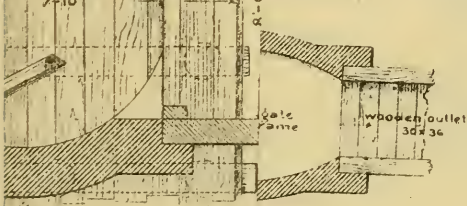
FOR 24" X 30" SEWER.
SS Section.



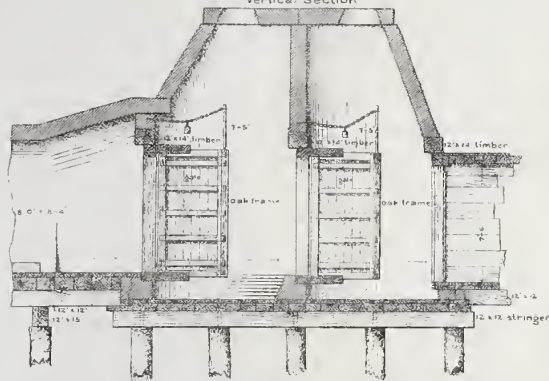
Section.



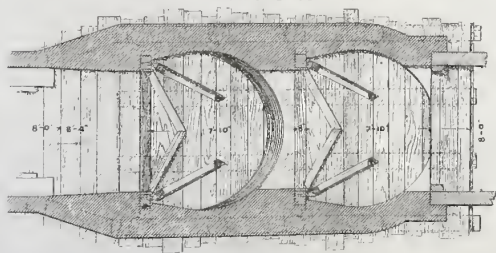
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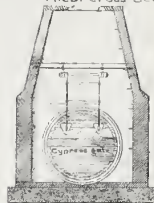
TIDE GATE CHAMBER FOR 8'-0" x 8'-4" SEWER.
Vertical Section



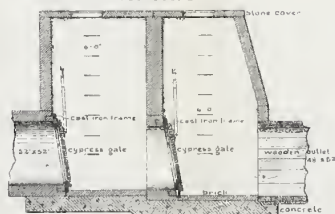
Horizontal Section.



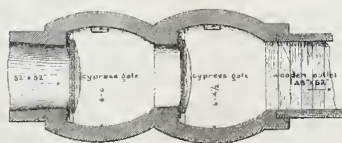
TIDE GATE CHAMBER FOR 32' x 52' SEWER.
Vertical Cross Section



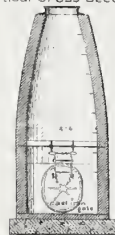
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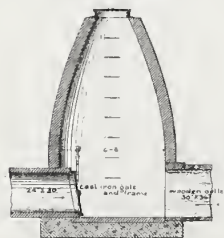
Horizontal Section.



TIDE GATE CHAMBER FOR 24' x 30' SEWER.
Vertical Cross Section.

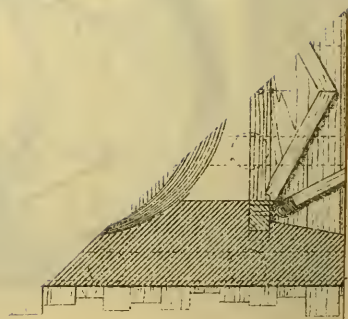


Vertical Section



Horizontal Section





A large sewer with double tide gates designed by Mr. Wm. H. Bradley was built from South Bay to the elevator; the outlet, as I remember it, was just above low water, and the upper portion was perhaps only a foot or two higher. The sewer was built large enough at its lower end to act as a storage reservoir for ordinary rainfalls, and the discharge, of course, took place at low water. There was very little head room for the sewer under the tracks, and this necessitated putting the tracks almost immediately on top of the brick arch. The sheeting was driven by a machine placed on a car and moved on the adjoining tracks. It is a good many years since this sewer was built, but, as I remember it, there was only an 8-inch ring under the track, and I recall very well, while the arch was still green and when the braces were taken out, seeing the arch rise at the top and crack. The braces were instantly restored and the track laid as quickly as possible on top of the arch, and I have never heard that there was any trouble arising from the construction, as trains have been running over it ever since. I do not cite this case as an example for engineers to follow, but rather as one for the younger members of the Society to avoid. The sewer as constructed certainly affords a large amount of relief.

MAINTENANCE OF THE SYSTEM OF SEPARATE SEWERS AT NEWTON, MASS.

BY STEPHEN CHILDS, M. AM. SOC. C. E. AND MEMBER OF THE BOSTON
SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, November 16, 1898.*]

THE maintenance of sewer systems is a subject upon which there is very little published information.

It is eminently useful that the various systems in and around Boston should be maintained at their utmost efficiency, and this result can best be accomplished by an interchange of ideas and suggestions of the various methods now in use. Toward this end the writer has been asked by your committee to give an account of those employed at Newton, not with the idea that they are models, but that mutual benefit may be derived from a free discussion of all methods.

The problem of providing Newton with a system of sewers was one that the growth of the city had long been demanding. It was not, however, until the Metropolitan Sewer Commission, by its plans for a trunk sewer up the valley of the Charles River, gave us the needed outlet through Boston's main drainage works to Boston harbor at Moon Island that definite plans could be made for construction.

Our system is known as the separate system, only house sewerage being provided for, and the sizes are therefore small.

Except in two or three cases, where it was possible to get rates of 4 feet in 100 feet, where 6-inch sewers are used, our minimum size of street sewer is 8 inches, and our largest is 24 by 36 inches.

A system of surface water drains which empty into the brooks or river is being built, as necessitated by the development of the city.

The city is composed of nine villages, separated by topography and local interests, each having its own business center and postal sub-station. These cluster around the various stations of the Boston and Albany Railroad and its Circuit Branch, so called, which now is developing three smaller villages.

The city is surrounded on three sides by the Charles River, and is intersected by four main brooks. The valleys of these brooks, together with the banks of the river, are therefore the natural locations for our main sewers, and in the plan for locations

*Manuscript received February 18, 1899.—Secretary, Ass'n of Eng. Socs.

these have been followed as closely as existing conditions would allow.

The Charles River Valley sewer of the Metropolitan system was commenced in 1890, and in the spring of 1891 contracts were let for sewers in the villages of Newton and Newtonville. These sections were completed in April, 1892; but the first house connection was made in October, 1891, so that some parts of our system have been in use over seven years.

Contracts were let for additional sections in 1892, 1893 and 1894, but, by the failure of several of the contractors and the fact that during these years our own men had done a portion of the work, with a considerable saving to the city, it was decided to so continue the work as fast as it was deemed necessary.

In this way eight of the nine villages mentioned have received the benefit of the sewers, and work is now begun on the ninth.

We have at the present time 83 miles of sewers in use, 65 of which are of 8-inch pipe.

For connecting houses with the sewer we make use of T branches instead of Y's. This gives a direct inspection from the "clean-out" at the wall of the house to the sewer, while the Y branch in most cases necessitates an eighth bend, which affords a possibility of solids so collecting that they could not be easily removed. As far as I know, in our seven years' experience, no harmful effects upon the flow of the sewage itself have resulted from the use of T's.

For house drains we use either 5-inch or 6-inch; 5-inch preferred by reason of its scouring better. The minimum rate is 2 per cent., although in some few cases 1 per cent. has been allowed.

As stated, our minimum size of street sewer is 8 inches, and the minimum rate for this size is 0.50 feet per 100 feet; and it seems to us that it would not be safe to reduce it, for in two or three cases, where it was necessary for a short distance to lay an 8-inch sewer at a rate of 0.40 feet per 100, some trouble was caused.

SYSTEM OF UNDERDRAINS.

Under all of our sewers (with the few exceptions where it was definitely known that the level of the ground water was much lower than the sewer grade) an underdrain has been laid. The size necessarily varies, our largest being 18 inches under one of our main sewers, and 4 inches being the minimum. The underdrain pipes are surrounded by screened gravel, and the whole is covered with a layer of bagging to prevent the clay from working down into the drain. This bagging does not rot until the soil

above has become so compact that there can be no tendency for it to settle into the drain.

The underdrains are so designed that they discharge at frequent intervals, either into convenient brooks or the Charles River; and, as they are inspected and kept free, together with the system of sewers, they furnish a continuous outlet for ground water, and are therefore of great advantage, especially in those parts of our city where the soil is compact clay and the level of the ground water high.

As an illustration of these conditions, the northwest slope of Hunnewell Hill is a location where previously it was almost impossible to build. Cesspools filled with ground water almost immediately after being dug, and remained so. Cellars were constantly damp and flooded after hard rains.

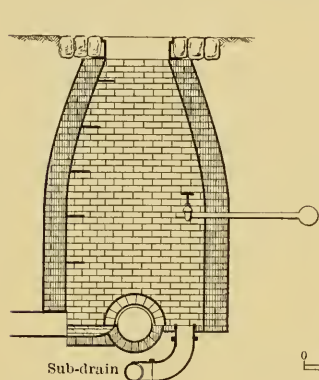


Fig. 1.

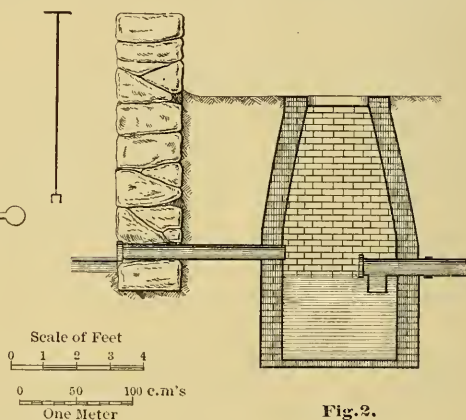


Fig. 2.

Since 1890 this neighborhood has become one of the most thickly settled parts, with desirable residences, in Newton, over seventy new houses having been built. The assessors' books show that the building of sewers and underdrains in this section, comprising an area of about forty-five acres, has increased the assessed valuation \$560,300,—a good return on the money invested.

Various plans of inspecting the underdrains at the manholes have been tried, but the one shown in Fig. 1 has been finally adopted, being inexpensive and easy of construction, allowing them to be flushed by inserting a piece of hose in the Y. No mirror inspection is required.

Most of our underdrains flow from half to two-thirds full much of the year, and some of them flow full; therefore little flushing is required.

The system is separated from the sewer pipes, and the opening into the manhole is closed with an iron plate imbedded in Portland cement.

One great advantage of the underdrain is during construction, when it insures a dry bed in which to lay the sewer, making a tight joint possible, reducing the level of the ground water and preventing leaks and the surcharging of sewers.

METHOD OF FLUSHING.

Our pipe sewers are systematically flushed with water from the city mains.

We have never used any of the patented automatic flush tanks for the following reasons:

- (1) Their first cost is greater than that of our method.
- (2) There is great danger of their getting out of order and either not flushing at all or allowing the flow of only a small stream of water, insufficient as a flush and wasteful.
- (3) They need to be inspected almost as often as our flushing manholes are used, and therefore require about as much labor.
- (4) In perfect working order they do not give as thorough and efficient a flush.

The flushing manhole used is shown in Fig. 1. A convenient water main is tapped, and a $1\frac{1}{2}$ -inch galvanized iron pipe laid into the manhole and closed by an ordinary $1\frac{1}{2}$ -inch wheel valve. Rubber-bound wooden plugs, similar to the one shown in the lower left-hand corner of Fig. 3, are then tightly inserted in the pipes opening out of the manhole. To these plugs are attached hook ropes reaching to the surface of the ground. The valve is opened by the key shown, the manhole filled and the plugs pulled out, one at a time.

If this operation does not completely clear any line of pipe, a manhole further down the line can be filled from this water connection and used as a flushing manhole.

A flushing manhole, as shown in Fig. 1, is placed at the summit of all lines of pipe sewer, and in some instances at manholes which are on sewers laid at a flat grade. Two men attend to this work. They have a three-wheeled pushcart in which they carry the different sizes of plugs and necessary tools, and also a set of three mirrors for inspecting the sewers.

The man in charge makes a report at our pipe yard every morning, showing the route to be followed during the day, and also the difficulties, if any found, on the day previous.

We are about to introduce the very efficient system of reports

which has been so successfully used by the city engineer of Medford, Mass.

We have at present 180 of these flushing manholes. The average cost of connecting a manhole with the water main in this way, including digging of the trench, tapping, piping, valve and refilling, is from \$11 to \$12, but depends, of course, upon the distance of the water main and the nature of the soil.

Our instructions to the men engaged in this work are to commence at the lower part of the system, working gradually to the summit, taking off every manhole cover as they proceed, cleaning out perforations, if clogged, and noting the condition of the line.

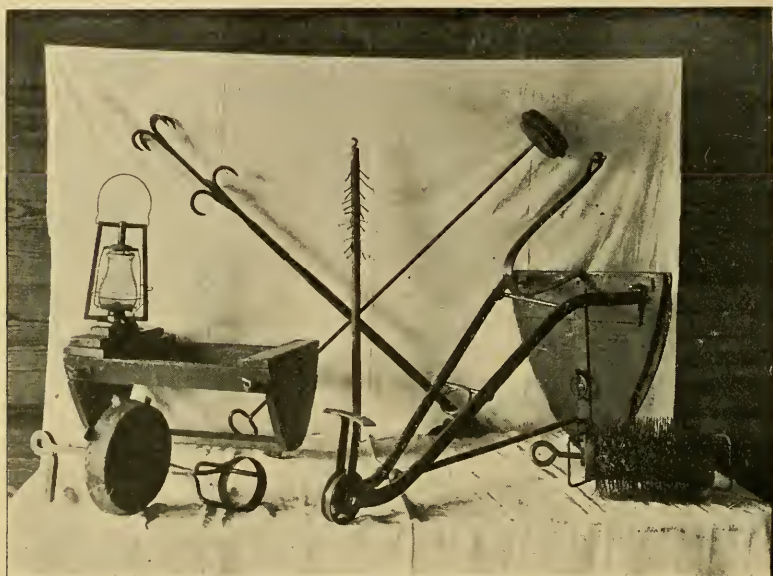


FIG. 3.

When the summit is reached, if the line is found to be clear and the flow unobstructed, the use of the flushing manhole is omitted. If, however, there is the slightest indication of any lodgment of solids the flush is used, and in bad cases one of the men is sent back to make sure the obstruction is removed.

It takes the men about three weeks to go over the 83 miles of sewer in this way.

This is hardly often enough in some parts of the city, and it will be necessary to have additional force when the system is constructed in the village of Newton Upper Falls.

Every one of the flushing manholes is used about thirteen

times a year. The quantity of water used is about 700,000 gallons per year.

Fig. 3 shows a group of implements used in cleaning and scraping sewers at Newton. The wire brush at the right and the jointed rods in the center are especially useful.

The systematic flushing of the smaller pipe sewers keeps them clear and in very good order. We find, however, that this is not sufficient to scour the larger pipe sewers and main lines laid on flatter grades. In the course of a year there collects in these mains, to a depth of from $\frac{1}{2}$ to 2 inches, a quantity of silt, a mixture of sewage and grease with fine sand and gravel, which undoubtedly sifts through the perforations in the manhole covers. Once a year, usually in the winter, this silt is removed by the various scrapers shown in Fig. 3.

The method is as follows: First, a bottle is floated through from one manhole to the next, dragging with it a stout line. Second, a strong rope is drawn through by this line. Third, any one of the scrapers or grapples needed is attached to the rope, and another rope to the back of the scraper. Fourth, the scraper is drawn through and the silt removed in buckets. Fifth, the scraper is drawn back and forth in this way two or three times, or until all silt is removed.

We begin the operation at the top of the flat grades and work downward toward the Metropolitan sewer.

The cost of this work averages \$80 per mile.

VENTILATION.

One of the most important factors in the maintenance of a sewer system is its ventilation. In Newton we depend for this upon perforations in the manhole covers and the use of the house stacks, extending through the roof unobstructed by the running trap. The perforations serve as fresh air inlets and the stacks as vent pipes, but the stacks in the valleys undoubtedly serve as fresh air inlets for houses higher on the hills. We have had no trouble whatever resulting from the removal of the running traps.

Our ordinance is permissive in this matter, and owners can retain the running trap if they desire, but we strongly recommend its removal; and of the 3400 houses connected, 2700, or about 80 per cent., are without the running trap.

Many of the objections urged, especially by the average citizen, against a removal of the trap are more fanciful than real. "I don't propose to allow your sewer system to ventilate through my house and the foul odors to escape through possible leaks into

my bedrooms" is the common exclamation of many a man to whom I have suggested the matter.

For a number of years he has perhaps had a cesspool in his yard, and on leaving home some morning after a good breakfast has gone out to see what the so-called "odorless excavator" is doing, and has peered into the cesspool and found the foul material there and a vile odor and gone away to imagine that all sewers are thus vile. Take such a man, as I have many times, to the nearest sewer manhole. Remove the cover and show him the stream of dirty water flowing unobstructedly in the sewer, and ask him if there is any objectionable smell from it. As a matter of fact, there is not in a system designed and operated as in Newton and in many other cities.

At least once in three weeks a quantity of pure water is turned into every sewer, which, together with the water used in the houses, so dilutes the sewage that it can not be objectionable.

Then, again, our plumbing regulations provide for the trapping and venting of each fixture in every house, and the testing of all pipes with the water pressure, which is of vital importance.

By this requirement and the direct passage of local gases and odors to the roof and open air the danger from leaking fixtures is overcome.

There remains the care of such gases as may arise from the decomposition of solids. This small remainder is nearly deodorized and absorbed by the quantity of pure water used in the flushing, the ventilation provided by the perforations in the covers and the free vents carried through to the roofs.

What would be the result if running traps were maintained? In the first place, other means of ventilation must needs be contrived, either by independent stacks, unsightly and expensive, or by some device of ventilating fans at the summits.

By trapping off every house you confine whatever gases are generated in the sewers, making them more like cesspools, and the possibility much greater of disagreeable odors rising from the perforations in the manhole covers. These gases, so confined, may collect in house drains so as to force themselves through the water in the traps (it takes very little pressure to do this), and then, if you have depended on your running traps for protection and have leaky fixtures or poorly vented ones, you are more exposed to danger than ever.

Mr. Frank W. Tower, plumbing inspector at Springfield, Mass., in a paper read at a meeting of the Massachusetts Association of Plumbing Inspectors, held recently in Boston, has given

some very excellent reasons for leaving out the running trap, some of which I will quote:

"First. They act as an impediment to the free scouring and cleansing, as the velocity of flow is greatly checked by the interposition of this trap.

"Second. Every trap, in plumbing work, is a filth-holder; and as sink waste usually contains more or less greasy matter, this is cooled in passing through a drain; and when this trap is reached it readily solidifies and sooner or later causes a complete stoppage of the trap.

"Third. A fresh air inlet or some relief pipe is a necessity at the rear of this trap to prevent air compression. The stoppage of this trap causes the fresh air inlet to act as the waste outlet for all matter discharged into the drainage system unless a fixture in the cellar is lower than this inlet, when the contents are discharged on the cellar floor.

"Fourth. When a fixture is discharged and the trap clear the foul odors generate into the house pipes and are forced through this fresh air inlet, which thus becomes a foul air outlet, and when opening near windows, which seldom can be avoided, causes serious complaint therefrom.

"Fifth. When a good inward and upward draft of air is produced, especially in cold weather, the cold air, passing over or near the water in this trap, chills and frequently freezes the trap contents, and then the filthy waste matter is discharged on the ground near the inlet."

These, together with the others previously stated, are good reasons why we feel that the dispensing with traps is an improvement rather than a source of danger, and the result of our seven years' trial of this method offers additional proof.

One especially good vent for a portion of our system has been gained by permission to connect the drain of the Silver Lake Cordage Mill with their 70-foot smokestack.

The perforations in the manhole covers are a source of some trouble to us in our maintenance work, owing to the quantity of surface water and dirt which thus finds an entrance into the sewer.

If streets could be always perfectly graded and manholes in the center of the streets where they belong this difficulty would be obviated. Dirt pans help this, and have been placed in some of the worst districts. These also prevent children from inserting sticks through the openings, which in one case, where no pan had been placed under the cover, caused a serious stoppage.

The method of keeping from the sewer sand from carriage washstands and straw from manure pits in stables is shown in Fig. 2. A simple brick catch-basin is built and furnished with a tight cover. This catch-basin is so located that a 5-foot length of 4-inch pipe reaches from it to the manure pit. Into the bell of this

4-inch pipe is fitted tightly a galvanized iron grating of about $\frac{1}{4}$ -inch mesh. The straw clogs this, and the owner must keep it clear and thus only the water gets away. The seal or trap is furnished by the special T used. This has a cover cemented into the bell end.

Where our underdrains are not laid at a depth of 10 or 12 feet we often find roots have worked through, closing the pipes. A simple and effective method of removing these is by the use of the rod shown in the center of Fig. 3. This rod is simply one of our jointed rods pierced by numerous wire nails. It is forced through into the mass of roots, twisted and drawn back, and usually brings most of them with it. A cutter for removing roots is also shown in Fig. 3.

The total cost of sewer maintenance in Newton for the year 1897 was \$2525.54. This total included all necessary repairs, supplies, tools and labor, there being no charge of the water department for use of water. At that time we had in use 77 miles of sewers, an average cost of \$32.80 per mile.

DISCUSSION.

MR. T. HOWARD BARNES.—I speak from the standpoint of an experience obtained mainly in connection with the separate system. The Medford, Mass., system differs but little from other separate systems of the Boston Metropolitan district. The minimum size of pipe is 8 inches, laid to a minimum grade of 0.50 per cent., where this is obtainable. As required in practice, we have one line of 0.20 per cent. and several of 0.30 and 0.40 per cent. grades. Six-inch pipe is used only at dead ends of laterals having grades at 22 per cent. or more. The system of flushing, as in the case of Newton, is by discharge from manholes situated mainly at the ends of laterals. Water services are, in most cases, laid into these manholes. Water connections are also laid at intermediate manholes on long, flat grades where the volume of sewage is small.

The length of sewers in use is about 43 miles, and there are 252 flushing manholes or inlets. Of this length about 72 per cent. is 8-inch pipe.

The ventilation of the system is accomplished by means of perforated manhole covers, together with those soil stacks on which the running trap is omitted. This omission is allowable on water-tested work in single systems, but the owner may elect whether or not the trap shall be used. In our practice the trap is generally used, the influence on the part of the plumbers and plumbing inspector being against its omission. Thus far there has been nothing pointing against the policy recommended by the

writer as above stated. I would not, however, expect the running trap to be omitted where the emanations from the stack would be a menace to neighboring dwellings. The plumbing ordinance, which leaves the matter in the discretion of the plumbing inspector, would guard against such occurrences.

One man, equipped with a one-horned pick and a broom tipped with a water-tap key, attends to most of the flushing and inspecting. His instructions are to observe at the first and second manholes in order to see whether any unusual accumulation is washed along by the discharge.

Owing to a lack of water services, some flushing is done by other means. A one-horse water cart, discharging through two 2-inch taps fitted with slide valves and enlarging to 3 inches on the outlet side, is used. This arrangement is very useful also on long lines where intermediate manholes can be filled and discharged. In these cases the plugs devised by Mr. F. B. French, of Woburn, are used to confine the water until its discharge. There are also several cases where a sewer extension has not reached a manhole point, and where access is had by turning up a bend opening into a manhole frame and cover at the surface. Such lines are also conveniently taken care of by the water cart. My observation is that the sudden release of the discharge is of great effect, creating a wave which scours the solids of the sewer. I should have stated that the regular flushing manholes are fitted with flap gates built in at time of construction.

Aside from flushing, the main requirements of maintenance are: the emptying of the dirt pans, gauging of the flow of sewage, care of the regulators at the Metropolitan sewer connections and the adjusting of the manhole covers to the changing elevations of the surface of the street. Considerable time is spent in plugging the holes in the manhole covers, or otherwise preventing the access of surface water.

During 1897 there were in use 225 flushing manholes (counting all, whether with or without water connections) and about 40 miles of sewers. The number of flushings was 2776, an average of once a month for each manhole. The cost was about \$550 for labor and team. The total expenditures for maintenance was \$1077. Reduced to miles, the cost for 1897 was \$13.75 per mile for flushing and \$26.92 per mile for all charges of maintenance.

It is found that the sewers need flushing every three, and some of them in summer every two, weeks. This is ascertained by the odor apparent after longer neglect.

This brings up the interesting point of frequency of flushing,

and upon this very point hinges, I believe, the mooted question of the relation of economy between flushing by hand and flushing automatically. By my experience, hand flushing once in twenty-one days will cost as follows, reckoning water at $1\frac{1}{2}$ cents per 1000 gallons (this, by the way, is taken for the sake of comparison with figures by Mr. Andrew Rosewater, in *Engineering News* of May 6, 1897):

Labor per manhole (when supplied with tap).....	\$1 53
Interest and sinking fund (5 per cent. of \$50).....	2 50
Water, 9000 gals. at $1\frac{1}{2}$ c. per 1000.....	14
Total	\$4 17

If we say (as does Mr. Rosewater) that flushing every day is required, our cost is as follows:

Labor	\$32 13
Interest, etc.....	2 50
Water	2 73
Total	\$37 36

In comparison with Mr. Rosewater's figures for automatic flushing, taken from the article mentioned, in which he states that a faucet may be adjusted to discharge 500 gallons once in twenty-four hours, we have,—

Labor maintaining tanks.....	\$6 67
Water at $1\frac{1}{2}$ c. per 1000 gals.....	2 73
Interest and sinking fund (5 per cent. of \$100).....	5 00
	\$14 40

Mr. Rosewater intimates, in the above-mentioned article, that the automatic tank cannot have its tap regulated to flow 500 gallons much more slowly than once in twenty-four hours. This conclusion the writer has heard stated orally by others. If, now, flushing be needed less often than once a day (which I believe), then we must compare the above-mentioned cost of \$14.40 per tank (which cannot be reduced) with \$4.17, the cost for hand flushing. Even if we say that a discharge twice in twenty-one days is required, or four times in that period, then the cost, respectively, is \$5.84 and \$9.18. If, further, a higher cost is assumed for water used, then the showing is still more favorable for hand flushing. The cost $1\frac{1}{2}$ cents per 1000 gallons is but little if any greater than that estimated for the Boston Metropolitan district, exclusive of the cost of the local distribution.

One item of maintenance not before mentioned is that relating to the particular sewers or house connections. Thus far, happily, the cost of this item has been very small. Upon about 1700 con-

nections less than a dozen stoppages have occurred, and of these but two were from causes in any way connected with defects of construction. These connections have all been laid by the department; no licensing of drain layers is practiced. Individuals are permitted to do the digging on their own premises. Five-inch pipe is used, connecting at the sewer by a $\frac{1}{8}$ bend and Y branch, and with a 10-foot length of 4-inch XH soil pipe.

A special expenditure for maintenance has been incurred this year,—viz, a systematic scraping of the system. This has been done by a gang of three men, at a cost, for labor, of \$336.55. In addition to this, material amounting to about \$50 has been consumed. The implement used was a scraper consisting of three disks of four-ply rubber gasket, separated about 10 inches and held by washers on an iron rod, forming what is known to some as a “jumbo” or follower. The disks were cut somewhat larger than the diameter of the pipe. A $\frac{3}{4}$ -inch braided cotton rope was used to pull or retard (as required) this jumbo. The leading rope was first pushed down the line of sewer by jointed rods from the flushing manhole to the manhole next below; the water was then turned on, rising back of the jumbo which had been entered into the line of sewer. When a head of from 2 to 4 feet was attained the implement was pulled along, scraping as it went; and the water, escaping along the peripheries of the disks, also assisted in scouring. Considerable sand and gravel were found and removed. There was also removed a skin of grease about $\frac{1}{8}$ inch thick and about 6 inches wide, which coated the sides of the sewers above and below the water surface. The rate of progress was quite variable, depending on the length of straight line and on the amount of sand or other extraneous material encountered.

The greatest daily progress was 8116 feet, the least 1148 feet. The total length was 195,377 feet. The permanent flushing man was paid \$2.50 per day, and each of the two helpers \$2.00. Rubber boots and oil suits were supplied them. Reckoning \$50 for material, the cost per foot was almost exactly 0.2 cent, the cost per mile about \$10.50. The sewers had been in use for periods varying from one to nearly three years. The points gained were a knowledge of where street material had entered the ventilation holes in the manhole covers, the removal of several brickbats and chunks of cement and the knowledge that the methods of flushing were maintaining the sewers in good sanitary condition. Aside from street dirt, the largest solid accumulations were films of grease, which were found of about $\frac{1}{8}$ -inch thickness at the water line of the sewage. These films of grease were nearly odorless,

and constituted all the greasy matter encountered. Where all the grease from house waste goes to I do not know, unless it is collecting on the sides of particular sewers. We have seen no evidence to show this, but it is a suspicion which I should like to have exploited. Traces of roots of elm trees were found in two cases.

Considerable attention has been paid to the matter of record of maintenance, especially of the flushing. Each flushing manhole is numbered, and has a line along which are entered the dates of discharge and any minutes of interest reported by the flusher. The latter is supplied with a book of daily report blanks. These are posted by the clerk. This record is simple, and has proved very convenient in giving exact history as to care in particular instances.

The gaugings of the discharge of the sewers are taken several times a year. But the total actual sewage being thus far small in comparison with the leakage, no interesting figures are deducible.

Constant care is exercised in order to prevent admission of surface water through ventilating holes of the manhole covers. They are plugged in whole or in part, and in many instances blank covers are substituted for open ones. The best endeavors, however, fail to prevent entirely the admission of surface water in times of slush.

MR. WILLIAM NELSON.—I have listened with great interest to Mr. Childs's very carefully prepared paper, and I will take your time for only a few moments in discussing a few of the points set forth. The city of Laconia, N. H., having a population of about 12,000, contains about $18\frac{1}{2}$ miles of sewers constructed on the separate system; arranged with two outlets into a lake having an area of about 12 square miles. The two outlets are 12 and 15 inches in diameter respectively, are composed of cast iron pipes and are each submerged for a distance of about 600 feet. The system is divided into two main lines, with outlets as described, into which empties a system of lateral branches. The longest main is about $3\frac{1}{4}$ miles from the outlet to the flush tank, and contains one 14-inch cast iron inverted siphon 100 feet long crossing a river, and having a dip below grade of 14 feet. The total cost of construction to date has been \$117,149.72, or about \$1.20 per lineal foot. This high figure is owing to some difficult and costly work on the main lines. The sizes of pipe run from 6 to 15-inch, in about the following proportions: 6-inch, 60 per cent.; 8-inch, 18 per cent.; 10-inch, 4 per cent.; 12-inch, 5 per cent.; 15-inch, 12 per cent., and iron siphons and outlets 1 per cent. The minimum grade, in feet per one hundred, is approximately represented by

the empirical expression $-\frac{2.40}{d}$, where d equals the diameter in inches, although we have one 6-inch lateral 725 feet long laid on a grade of 0.26 feet in 100 feet. This sewer has given no trouble whatever, and is automatically flushed with a 250-gallon flush tank discharging once in about eighteen hours.

The gentlemen who have preceded me did not speak favorably of the automatic flush tank, and, as we have had about seven years' experience with these fixtures, it may perhaps be well for me to take up their defense. The system just described contains eighty-three Rhoades-Williams automatic siphon tanks having 5-inch siphons, and two larger tanks, to which I will refer later. These flush tanks have 8-inch brick walls laid in cement mortar and a 6-inch concrete bottom, and are painted on the inside with a thick cream of Portland cement. Their first cost was \$65 each, and the subsequent charge for maintenance has been very light, this year averaging 72 cents per tank, including all labor and material, although in some years it has averaged as high as \$3.60 per tank. This reduction in cost of maintenance is owing to close attention to many small details to which I have given a great deal of time. In Laconia flush tanks are used under peculiarly trying circumstances, as the water works plant is owned by a private corporation, and water is sold to the city for flush tank purposes at 18½ cents per 1000 gallons, measurement being made by timing the discharge of a known volume as regulated by a small pet-cock in the supply pipe to each tank. Much difficulty was experienced in setting these small cocks to discharge the proper quantity in the right time, and when they once were set the size and shape of the streams were such that they were very often stopped entirely by sediment in the water. To overcome this I placed upon the discharge pipe in each tank a ¾-inch nickel-plated hose bibb, and fastened to this a phosphor-bronze disk with a hole of the proper size to discharge the required quantity of water under the head, which was measured by gauge at each tank. To fasten the disk to the hose bibb I used a common ¾-inch female hose coupling, in which was placed, first, the disk, then a washer, then a disk of very fine wire gauze, then another washer. This arrangement made a tight job, and it has given perfect satisfaction. The holes in the disks varied in size from 0.0223 to 0.0307 inch, and were bored with small twist drills. Careful experiment showed the coefficient of discharge to be 70 per cent. This arrangement requires attention about three times during the year, and admits of very close and reliable regulation. The hole in the disk gradually enlarges, and a new disk is required about once in two years. The

cost of water used under the excessive rates, as quoted, is about \$12 per tank per year. Another detail which gave us no end of trouble was the Portland cement plastering on the inside of the tanks, which was continually cracking off, owing to the action of frost, and allowed the water to escape from the tank as fast as it entered. This defect was remedied by cutting off all the old cement and painting with three coats of thick Portland cement cream. No trouble has been experienced since. One of the large flush tanks, to which I have previously referred, is supplied with water for its operation from the waste pipe of a watering trough, and is designed to flush a short line of 12 and 15-inch pipe laid upon a flat grade. The quantity of water received from this source is much larger than one would suppose, and in this case is sufficient to discharge the tank (750 gallons) about three times per day. The other large tank is a raw sewage flush tank, designed to operate with the natural flow in the sewers, and, in flushing, to clean a 12-inch iron inverted siphon about 171 feet long, crossing a river. To sum up the flush tank question, I will say that in my experience during the last seven years I have found their use, in connection with the separate system, to give cleaner sewers, to allow the use of flatter grades and to reduce the cost of maintenance as compared with the system described by the author.

The city of Laconia has an ordinance which provides that house connections shall be laid by a licensed drain layer who is under \$500 bonds for the faithful discharge of his duties. Every connection is laid to a line and grade fixed by the city engineer, and connects with the main sewer by means of a $\frac{1}{8}$ bend and Y branch. The alignment is made straight from the sewer to the inside of the cellar wall, a Y branch being placed just inside the wall with a brass clean-out in the end. No trouble has been experienced with stoppage in the $\frac{1}{8}$ bend. The minimum grade is 1 : 60, and the connections are all 4 inches in diameter. To place, cause or allow to be placed a running trap or any obstruction to the free flow of air throughout the whole course of the drain and soil pipe in Laconia is a misdemeanor punishable by a fine not exceeding \$20. The system is thus ventilated through each house connection, and we have found this arrangement very satisfactory. The trouble with roots of elm trees, spoken of by Mr. Childs, has taken place in Laconia, and we have found that this was owing to defective cement joints. To remedy this I have replaced the section affected with extra wide and deep socket pipe which allows a good chance for making the joint, and which, to my mind, represents a distinct advance in the manufacture of

sewer pipe. We now use this pipe in all new work. Within the past seven years we have taken up and relaid about 275 feet of pipe on account of tree roots.

In the maintenance of iron inverted siphons in use in Laconia we have found no especial difficulty, and, contrary to the general supposition, we have found less tendency to the formation of deposits in the siphons than in the sewer lines. In the 14-inch siphon which I have mentioned some sand collects in the lowest point, but is easily washed out by the use of a wooden ball at the end of a rope carried along by the water used in flushing. Notwithstanding the use of automatic flush tanks, it has been my practice to flush both outlets in the spring, and the whole system complete in the fall. This work is performed by five men with a team to carry tools. We put through the wooden ball fastened to the end of a No. 8 braided cotton window cord, which is carried coiled on an ordinary garden hose reel. The diameter of the ball varies from $\frac{1}{2}$ to 2 inches less than the diameter of the pipe for which it is intended, and is made of rock maple. The ball is forced along by water taken from fire hydrants, and in its passage through the pipes produces the best scouring and cleaning action of anything that I have ever seen, the water damming up behind the ball and falling forward by the sides at great velocity. The divided stream, meeting at the bottom of the pipe just in front of the ball, loosens up all deposit and partially floats solids so that the ball easily carries them along to the next manhole. In a 6-inch lateral we have pushed along in this manner, for a distance of 125 feet, an egg-shaped stone measuring 5 x 7 inches. As each manhole or lamp-hole is reached a man with a pole having a strong hook at the end hooks up the line, and, after pulling out on the ground all the line behind the ball, proceeds to let it slowly move to the next opening. Much ground can be covered in this manner at a small cost. The total cost per mile for flushing for the past year has been as follows: For labor \$8.24, for water \$6.50, making a total expense for cleaning during the year, outside of flush tanks, of \$14.74 per mile. Very little trouble has been experienced with sand in the sewers. The worst case was caused by the bursting of a large water main, which carried away about fifty feet of sewer and filled a 12-inch main about half full of sand for a distance of 600 feet. This was removed within a short time by means of a new sand scraper which I had made at a small cost. This scraper is illustrated and fully described in *Engineering News* of April 25, 1895, to which your attention is respectfully directed.

In closing, I desire to say that the subject, as presented by

Mr. Childs, is to me one of the most interesting in engineering, and for that reason I shall have to ask your indulgence if I have taken up more of the time than I was allotted.

MR. BERTRAM BREWER (by letter).—The thickly settled and sewerred portion of Waltham, Mass., comprises only about one-fifth of the whole area of the city, while the population reached by the sewers is about six-sevenths of the whole. Our system therefore is comparatively compact and easy to maintain. We have but one connection with the Metropolitan trunk line, and that is at the lower end of the city, where Waltham joins Newton. The Waltham system comprises about 37.67 miles of sewers, and the average cost per running foot has been \$1.94.

Very few of the sewers have permanent underdrains under them, and temporary ones were used only where absolutely necessary for construction. Without going into the question of the advisability of a complete system of underdrains, I would say that the Waltham sewers have cost much less than would have been necessary had a complete system of underdrains been adopted.

Since 1896 we have been introducing, as rapidly as possible, the method of flushing the sewers by means of valves in the manholes directly connected with the water mains. The pipes are plugged either by wooden plugs or by iron flap valves used to close the outlets while the manholes are filling. When the manhole is filled the valves are raised or the plugs are removed, and the whole orifice of the pipe is suddenly filled with a stream of water which flushes in a very satisfactory and economical manner. The water department also considers this a good thing, as dead ends, where they occur in the water mains, frequently receive a thorough clearing out by means of our regular flushing. We aim to flush all our sewers at least once a month, except in the winter season.

While drain layers are licensed in Waltham, the city has, from the beginning, done all the work in the streets, and in the majority of cases in the private lands as well. As sewer connections are being constantly laid in the season, we are compelled to have a permanent force on hand, and this force is also used a portion of the time on maintenance, which time is, of course, charged to the maintenance account. The sewer system was completed and connections were made in the latter part of 1893, and we have at present about 2215 connections. By careful management, the yearly cost of maintenance for the main sewers has been decreased from \$4500 for the year 1894 to \$1700 in the twelve months of 1898.

It has been my intention to classify the different parts of our system and to prepare a monthly record of each section, so that a

monthly account of the condition of each part of the sewers will be preserved, together with additional statements in regard to the exact date of the flushing and any other notes of interest. With the coming year I propose to put this into effect. I have, moreover, had a very strong desire, and am glad of this opportunity to express it, that some form for reporting on the various details of maintenance should be adopted. Just as the New England Water Works Association has prescribed a form by which the various facts of interest of the water works systems of the different cities and towns may be preserved in uniform style, so I think the interesting facts regarding the sewer systems of the various cities and towns represented in our Society should be tabulated in uniform style for purposes of comparison and instruction. I should be very glad, indeed, if something were done to bring this about through this meeting and discussion of our Society.



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This Association is not responsible for the subject-matter contributed by any Society or for the statements or opinions of members of the Societies.

MECHANICAL INFLUENCE IN ARCHITECTURE.

BY G. W. PERCY, MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

[Read before the Society, March 3, 1899.*]

IN most popular writings on the subject of architecture and of the origin and development of architectural styles, the causes that are chiefly dwelt upon as affecting and influencing the forms and features of the various styles are, climate of the country, temperament of the people, their artistic tastes, religion, traditions, occupations, etc.

In short, the esthetic and sentimental influences are credited with being the most important factors and the controlling causes in developing their national styles.

Thus we are often reminded that the light and peculiar constructions of the Japanese and Chinese are but the natural representations of the nature and characteristics of these peculiar peoples; likewise, that the massive grandeur and simple severity of Egyptian architecture but reflects the somber, austere and rigid character of the ancient Egyptians and the impressive rites of their religion; that the beautiful and majestic marble temples of Greece are but expressions of the artistic and philosophic nature of the Greek mind, while the round arch of the Romans was introduced for the gracefulness of its lines and purely for decorative effect; that Romanesque architecture was but the result of a different whim, and a desire on the part of the early Christians to cultivate a style different from that of pagan Rome.

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When we come to Gothic architecture, imagination runs riot in accounting for the pointed arch and groined vaulting on sentimental grounds, and attributing to the desire to produce picturesque effects such features as the graceful pinnacles, flying buttresses and strong projections, while the lofty spires and high-reaching roofs are supposed to indicate the earnest desire of the soul to follow in the direction of the heavenly index.

While I am quite willing to admit that these and similar sentimental and esthetic reasons have made their impression on architectural styles, more especially on the decorative and ornamental portions of the work, I shall attempt to show that by far the most influential factor in perfecting nearly all strictly archi-

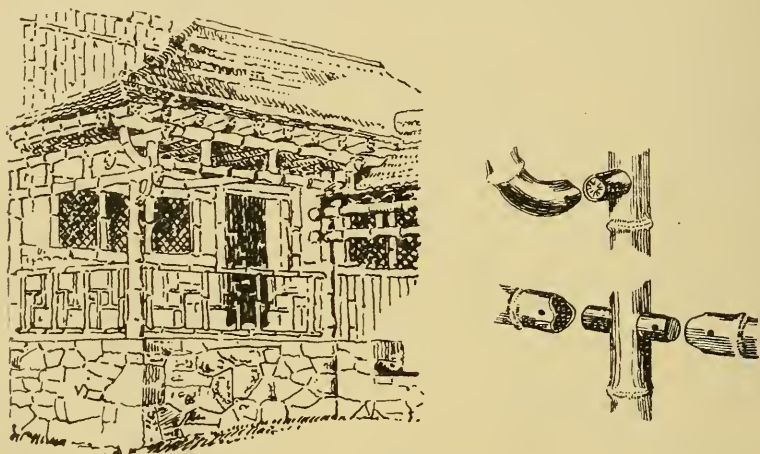


FIG. 1. CHINESE.

tectural forms has been purely mechanical, in devising the best methods of employing the materials at hand, and the means used to overcome structural difficulties and resist natural forces.

In following out this idea while examining historical styles, we shall see that generally the builders used the best judgment, skill and methods at their command, even when it led to changing forms that had become sacred by tradition and association; while sometimes, as in the case of Egyptian architecture, we may find forms and details naturally developed in one kind of material were religiously copied in other materials where they ceased to be appropriate.

So closely has all good architecture in the past followed the rules of good construction that the motto "*Construction may be ornamented, but ornament should not be constructed,*" has become

proverbial, and a very able architectural critic lays down this rule of judgment:

"A form which admits of no explanation, or which is a mere caprice, cannot be beautiful, and in architecture every form which is not inspired by the structure ought to be rejected."

Of the surface ornaments applied to their architectural forms by the Egyptians and other peoples I shall have nothing to say in this paper, more than to observe that they consist principally of conventionalized forms of the flowers and foliage of the country where used, and of religious emblems; and that their application is conceded to be due to esthetic and religious sentiments.

As graphic illustrations will show architectural forms more clearly than words can describe them, I have prepared a number

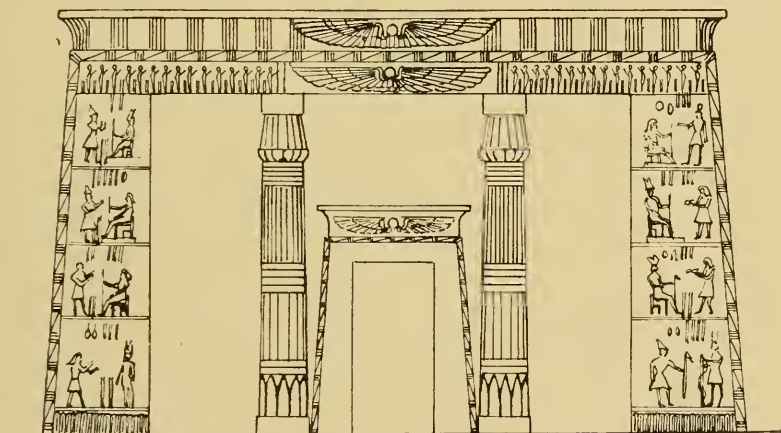


FIG. 2. EGYPTIAN.

of sketches to illustrate my meaning and make my references more clearly understood.

Without wasting time to speculate on the origin and forms of prehistoric architecture, we will refer at once to well-known forms of historic times and work. In Fig. 1 are presented some simple forms of Chinese construction, in which is shown quite clearly the bamboo origin of Chinese architecture.

The properties of the bamboo are well known, and in a country where it is found in abundance, from the smallest twigs to trees 6 and 8 inches in diameter, its great strength and remarkable lightness, together with the fact that it is uniformly hollow, with webs at intervals, so that one part may slide inside a larger piece, the ease with which sockets and doweled joints may be made and

secured, and other conveniences of application, were sufficient reasons for making this the principal material for house building, and the forms adopted are such as would naturally be developed in the continuous use of this peculiar material, regardless of the sentiments or characteristics of the people.

In lower Egypt we find quite different conditions and surroundings. See Fig 2. With few trees of any kind and with no stone immediately at hand, the early Egyptians erected their dwellings and other buildings with mud, reeds and bulrushes, which they had in abundance.

On elevated platforms of earth they erected thick walls of mud, placed *in situ*, with layers of reeds and bulrushes to bind the whole together. For greater stability they made the walls battering on the outside, thus reducing the thickness as they approached the top.

To enable them to preserve true angles and proper batter, at the angles of the proposed structure they set up corner posts, consisting of bundles of reeds, neatly tied at intervals with willows or smaller reeds.

A horizontal band of similar bundles of reeds marked the top of the wall proper, and where the thick mud roof should commence. This roof was supported by bundles of reeds laid close together and in turn supported by the walls, and by interior columns of proper strength. These columns also consisted of large bundles of reeds strongly bound together.

To confine the mud or soft clay when applied to the roof, upright reeds were placed close together and secured to the horizontal band. These would naturally bend outward from the pressure of the clay on the inside, and thus produce the graceful and bold cove which forms so conspicuous a feature in Egyptian architecture.

These early structures were plastered on the outside with clay, in the fresh surface of which were easily impressed ornaments and hieroglyphics.

When this people had so far advanced as to build their temples and tombs of granite, the traditional and still prevalent forms of their mud structures were copied to the minutest detail.

Even the massive stone columns in their latest work, in many cases, show very clearly their reed origin, with well-designed capitals of lotus, papyrus and palm, reminders of the flowers and leaves with which the earlier columns were sometimes trimmed or decorated.

The ornaments and hieroglyphics so easily impressed in their

mud walls were now cut with great difficulty in the hardest known building stones.

And this simple style, thus developed, was practiced as long as Egypt was a power.

The monuments of this ancient art still remaining give us on their sculptured walls the best history we have of their arts and sciences.

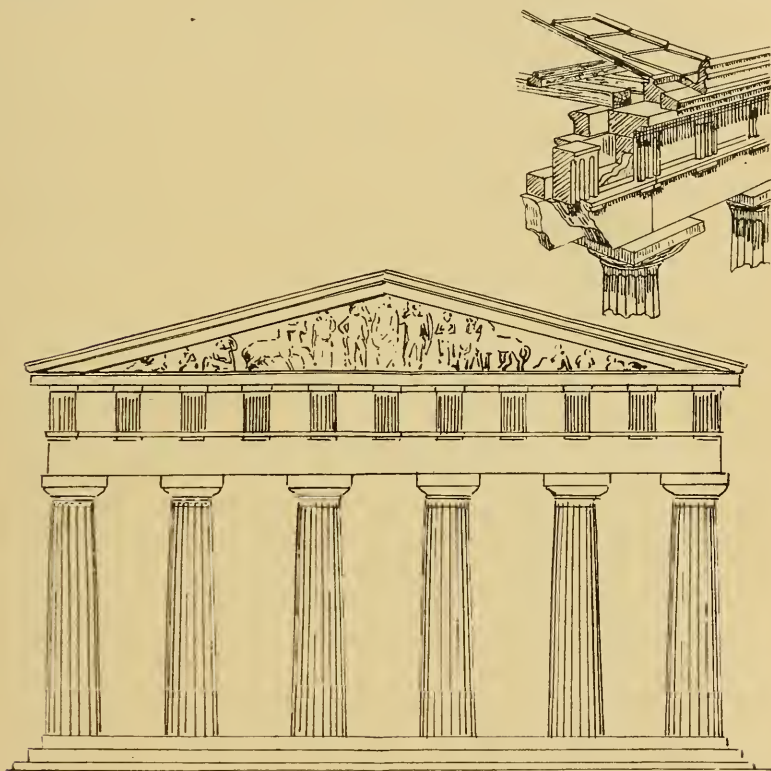


FIG. 3. GRECIAN.

The development of Grecian architecture advanced on quite different lines, and it shows less clearly in the perfected temple the details of its prototype. See Fig. 3.

The early habitations of Greece are generally conceded to have been of wood, and the log hut, with its projecting porch supported on upright trunks of trees, is supposed to have suggested the form of the marble temple and portico.

As Greece abounded in marble and limestone easily obtainable in large blocks, the inhabitants commenced, at an early stage of their development, to build with stone; but, instead of slavishly

copying the forms and proportions of log structures, they did what we should expect of a people who could evolve logic; they devised and perfected forms and proportions more appropriate for their stratified materials.

Instead of making their columns monolithic, placing the natural strata on end, they cut cylindrical sections from the thickness of the layers in the quarry. Then, cutting square holes in the center of each end, they inserted square blocks of wood, in which were fixed axles of a frame, and in this manner the great drum-like sections were rolled over the ground to the site of the proposed structure, where they were wrought to the desired size and exact form, and carefully placed in position. The Grecian columns are much more massive and set nearer together than could have been suggested by wood construction. The spreading cap and broad abacus were designed to shorten the span of the lintel and give it greater bearing surface, at the same time giving level supports for timbers on the outside and inside of the entablature, which should serve as scaffolding and guides in placing the architraves in their exact positions. The architrave itself was made double for greater security from defects in the stone, the triglyphs and frieze to give satisfactory proportions and furnish a protected position for sculpture and ornament, while the cornice projected sufficiently to discharge the water well away from the walls. The low-pitch pediment emphasizes and makes clear the lines of the roof and explains its purpose.

The general form and application of all these parts are strictly adapted to the work they have to perform and to the materials in which they are executed, while the graceful forms of the mouldings, the flutings of columns and ornaments of capitals and friezes, must be credited to the artists' touch after mechanical considerations had produced the general forms.

In Greek work each stone is very perfectly wrought to its proper lines and surfaces, and the blocks are fitted together with the greatest exactness, the abutting surfaces often being polished. Dowels of copper or bronze were inserted in the joints to prevent displacement by earthquakes, and no mortar was used. It was this perfect mechanical work of the Greeks that inspired Longfellow to write:

"In the elder days of art,
Builders wrought with greatest care
Each minute and unseen part,
For the Gods see everywhere."

In Rome we find still different conditions, and to meet them new mechanical principles are involved. See Fig. 4.

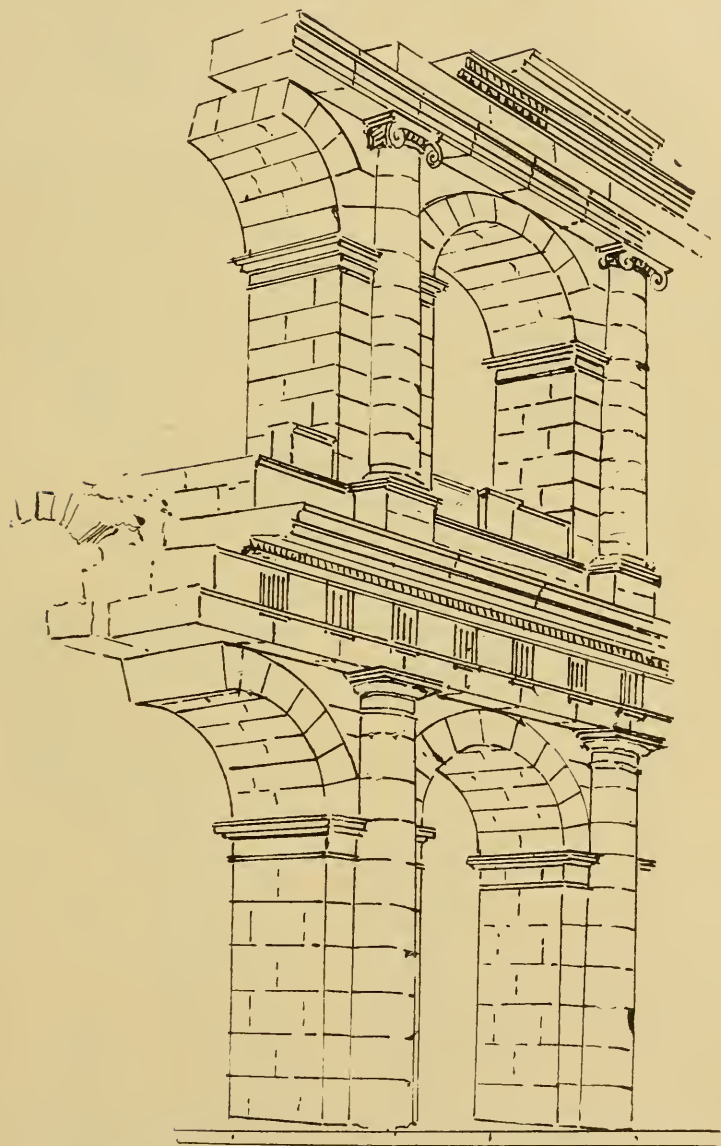


FIG. 4. ROMAN.

Unlike Athens, the immediate vicinity of Rome did not furnish marble or other stone suitable to be used in large blocks. A soft volcanic tufa abounded, with which the early Etruscans developed the semicircular arch as a means of spanning openings instead of the horizontal lintel.

The discovery and first use of the arch can not be positively accredited to the Etruscans.

It was probably in the valley of the Euphrates, where sun-dried and burnt bricks were the building material, that the important discovery was made that a wall of masonry could be safely carried over openings by the use of small wedge-shaped blocks placed with the large ends outward so as to form an arch or bow over the opening. This discovery was destined to play an important part in architecture. In fact, all styles may be divided into two classes, that of the lintel and that of the arch.

The Romans carried the development of this principle to a high degree of perfection, and the round arch became the essential feature of the early Roman construction.

When, at a later day, they conquered the Greeks, they transplanted Grecian architecture to Rome only to decorate their own arched construction.

Instead of the arch being used as a decorative feature of Roman work, it is the vital principle of construction, while the Greek orders were applied literally as appendages, very much as trophies of conquest were carried in their triumphal processions or displayed in their forums.

A Roman monument may be deprived of all its decoration and its apparent form removed without prejudice to its structure; as, in many cases, the Greek orders have been stripped from their buildings for the sake of the marble, and the real Roman construction stands forth in its native dignity, as may be seen in the three great arches of the Basilica of Constantine, the ruins of the Baths of Caracalla and those of Diocletian, and in the better preserved walls and dome of the Pantheon.

The latter building, remaining to this day the largest dome of masonry in the world, is a good example of the Roman method of resisting the thrust of arches with great masses of inert material and not by active opposing forces, the walls of the Pantheon being twenty feet thick and the dome of great thickness of solid concrete, with ribs of brick.

The extensive use of small stones, brick and concrete in Roman work necessitated the use of mortar to fill the interstices

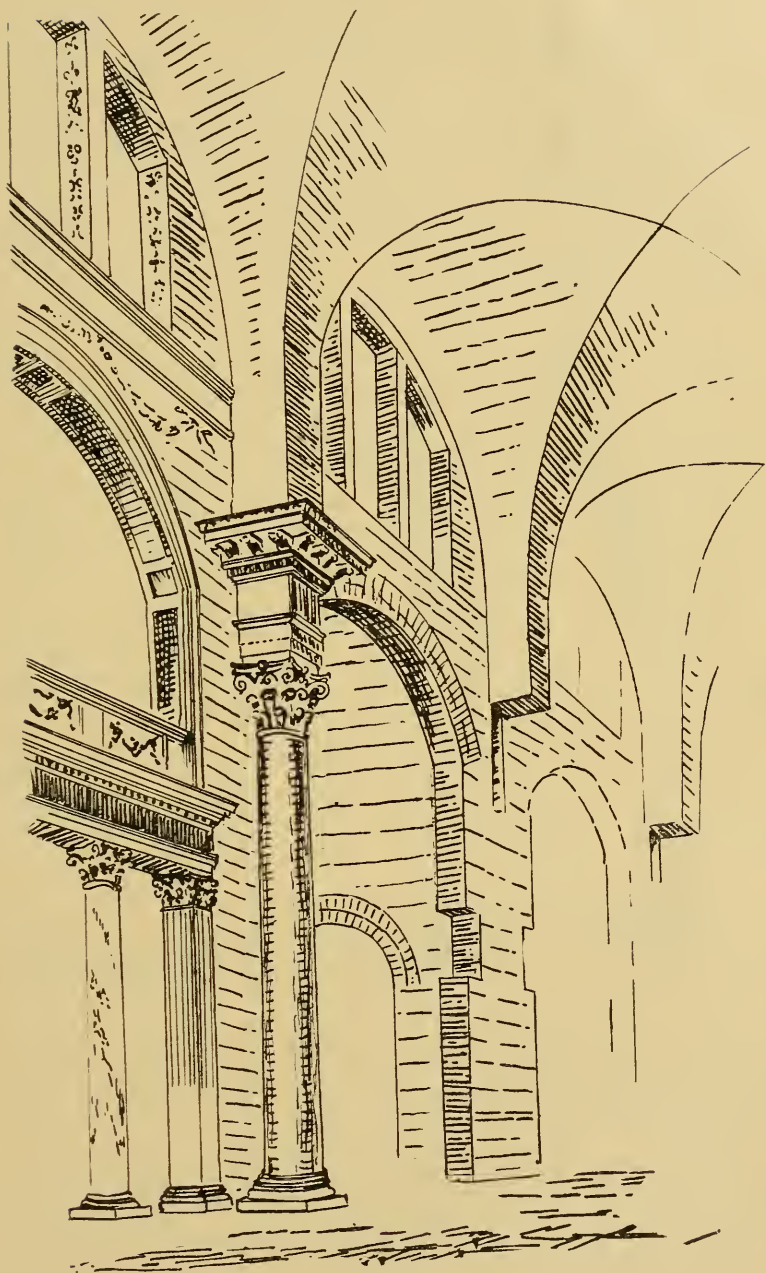


FIG. 5.

and bond the whole together. In this material the Romans excelled all builders down to very modern times. See Fig. 5.

It may appear presumptuous to criticise the Roman combination of arched construction and the Grecian linteled orders, as such work is considered classic and is much copied in modern times. We shall see, however, that the next great change in architectural style, the introduction of the Romanesque, was not the result of Christian prejudice, but of Greek logic applied to building construction. When, in 330 A.D., Constantine established the seat of the Roman Empire at Byzantium and undertook to erect monuments that should rival those of imperial Rome, he employed, for the purpose, Greek architects who had not been completely subjected to the dictations of their Roman masters, and who were allowed to exercise their mechanical knowledge and artistic tastes in erecting the required buildings.

These men, with logical minds, and having not only the benefit of experience with Roman work, but the actual materials taken from the many ruins of Roman work to build with, adopted a new combination, which, as we shall see, was purely structural. See Fig. 6.

The value of the arch, as developed and employed by the Romans, commended itself to the Greek mind as not only the simplest and most economical method of spanning openings, but the only practical method of covering large ones.

They saw, however, that when arches were used to carry the superincumbent weight, the entablature, the essential and most expensive part of the classic orders, was utterly useless, and they did not hesitate to discard it.

Taking the columns, which were brought from Rome, they set them up as the supporting members, and, adjusting capitals with stronger forms and larger abacuses, they turned the Roman arches directly from the tops of such capitals, and by this simple mechanical device was given to the world the Byzantine or early Christian architecture, the progenitor of all Romanesque styles, quite as logical and mechanical in its way as was that of the early Greeks.

The example thus set in the East was soon followed in all parts of Europe. Even in Rome itself, the fallen entablature was allowed to lie dormant and in disgrace for nearly a thousand years.

Dispensing with the classic entablature was not the only suggestion given to the world by the Byzantine architects, for, in their grandest monument, the church of Santa Sophia, we have the

results of the first attempt, on a large scale, to resist the thrusts of domes and vaultings with counter-thrusts.

The church, as built under Constantine, doubtless had a wooden roof and was destroyed by fire about 525 A.D.

Under Justinian it was rebuilt on a grander scale and with vaulted ceilings and stone dome 104 feet in diameter. The ambition of the architect Anthemius exceeded his scientific knowledge of the lateral thrust of such construction, although he planned very ingeniously to resist the thrust on the north and south sides

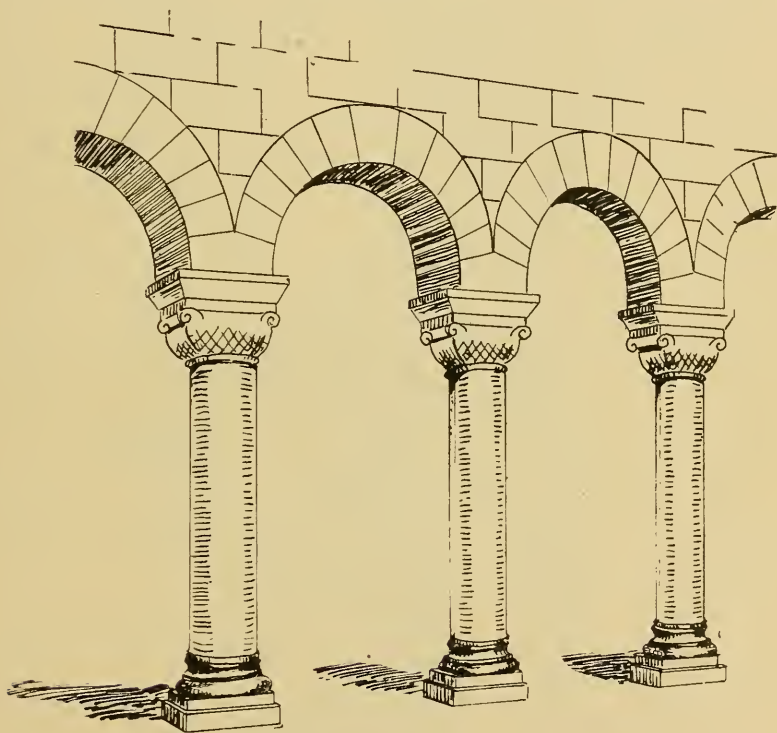


FIG. 6. BYZANTINE.

by means of immense hollow buttresses extending across the side aisles to a distance of 90 feet, and on the east and west sides with half-domes of the same diameter as the central one. These half-domes were again buttressed by smaller half-domes and lateral arches. Still the great dome had not been finished when it gave way on the east side and fell, carrying with it the half-dome on that side.

After this disaster and the death of Anthemius, the superintendence of the work devolved on Isidorus of Miletus, who

strengthened the piers, built buttresses against the east side, threw flying arches from the great side buttresses and filled up the large arches on the north and south sides with small arches in three stories.

With these and other devices, and by using the lightest stone obtainable for the dome, Isidorus succeeded in finishing the building in such a manner that it has stood for over thirteen centuries and in more modern times has been copied many times on a smaller scale for Turkish mosques; and the appearance they present of an attempt to pile dome on dome is the simple result of buttressing the thrust of a large dome with several smaller ones.

As the expedients employed to overcome mechanical failures have often given new and acceptable forms to architecture, so unremedied failures have sometimes been applauded as great achievements. For example, I have often read in magazines and popular newspaper articles great praise bestowed on the builder of the Leaning Tower of Pisa, attributing to him a desire and ambition to erect a monument that should appear to challenge the very laws of nature, and a marvelous degree of success in that direction, when in fact the slightest intelligent investigation will show that the tower was built vertically and commenced to settle to one side before the two upper stories were built. These again were built vertical, when further settlement threw them out of plumb, but of course to a less extent than the lower stories.

Notwithstanding its great inclination, the center of gravity is several feet within the supporting lines of the base, but it is not recorded that a laurel crown was conferred on the architect in recognition of his brilliant achievement.

It was by such failures, and many more disastrous ones, that the lesson of safe building, especially of equilibrium in arched and vaulted constructions, was learned.

During the eight centuries that Romanesque architecture prevailed, there was a growing desire and effort to render churches and other structures fireproof by means of vaulted ceilings and roofs. These ceilings, arched with brick, stone or concrete, often pushed out the massive walls and the building collapsed.

To prevent this, plain, square buttresses were built on the outside to assist the walls in resisting the thrust of the arches. These buttresses, often built after the defects manifested themselves, soon became conspicuous in the designs and therefore a feature of the style.

As the ambition of the Church seemed to run to larger and higher edifices, the difficulties in resisting the thrust of these inte-

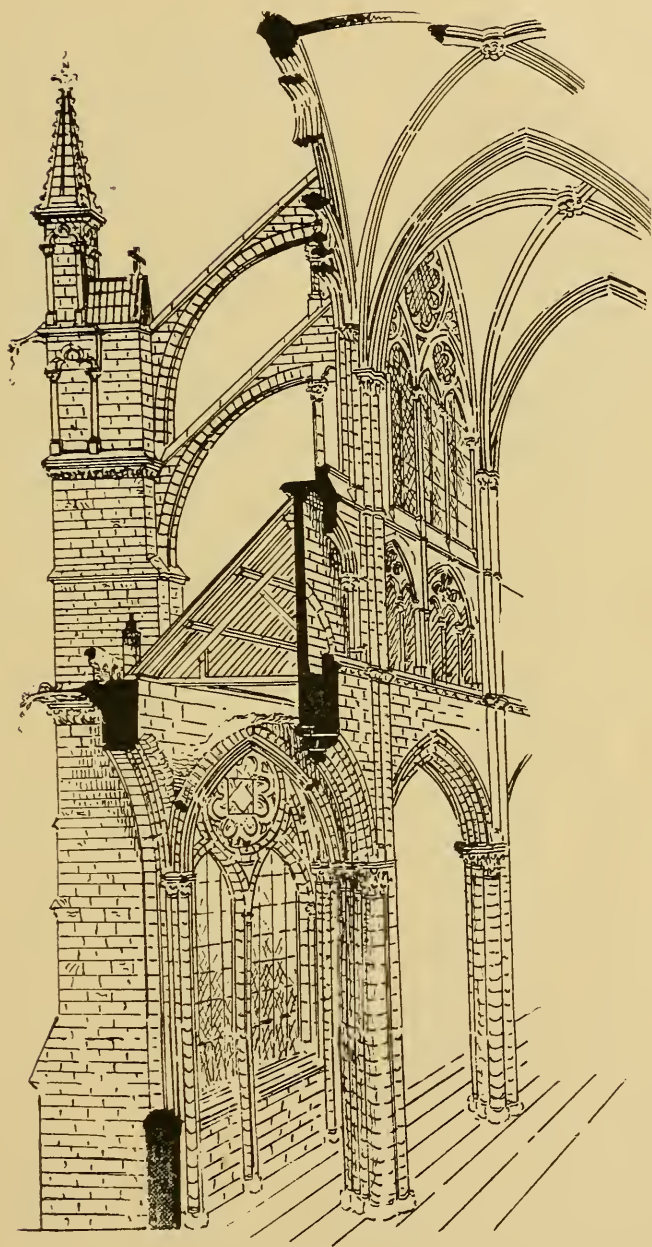


FIG. 7. GOTHIC.

rior semicircular vaultings increased rapidly, and the skill and ingenuity of the builders were taxed severely to meet them.

Other difficulties arose in using the round arch with churches having different widths of nave and transepts and still different lateral openings. The arches could not be brought to a uniform height, the intersecting lines were awkward and the general effect often unpleasant.

In the early part of the twelfth century, while the builders of the mediæval churches were struggling with the difficult problems presented, a happy solution was evolved in the pointed arch. See Fig. 7. The many advantages of this form of arch soon became apparent, and the round arch, with all its sacred traditions and venerable service, was abandoned at once; for this new and advanced step in evolution was a necessity, reducing the thrust of the vaulting about one-half and allowing arches of many different spans to be brought to a uniform height with graceful intersections and secure construction.

The pointed arch not only solved the mechanical difficulties of this church-building age, but lent itself so naturally to the upward tendency that a new impetus was given, and churches and cathedrals, designed and commenced in the Romanesque style, were often carried up in the Gothic style to a much greater height than the original designers had dreamed of.

The intelligent application of the pointed arch to interior groined vaulting soon brought about the complete system of Gothic architecture, in which the entire load and active thrust of the vaulting are concentrated at individual points, and the weight is transmitted to the ground by slender piers, while the outward thrust is met by flying buttresses reaching over the roofs of the aisles. These flying buttresses, instead of springing from thick and massive walls, rest against deep buttresses which may be considered as so many sections of the old Romanesque walls, placed at right angles to the building line.

In this ingenious and scientific manner the thrust of the lofty vaultings is conveyed to the ground without obstructing the light required for the building, and at the same time it produces a charming effect.

The stone pinnacles crowning these buttresses were erected, not to give variety to the outline, or simply to send up so many aspiring points, but for the more prosaic purpose of lending their weight to secure equilibrium for buttress and flying arch.

The roofs of towers, which at first were of flat pyramidal form, became elongated to the tall and graceful spires of later

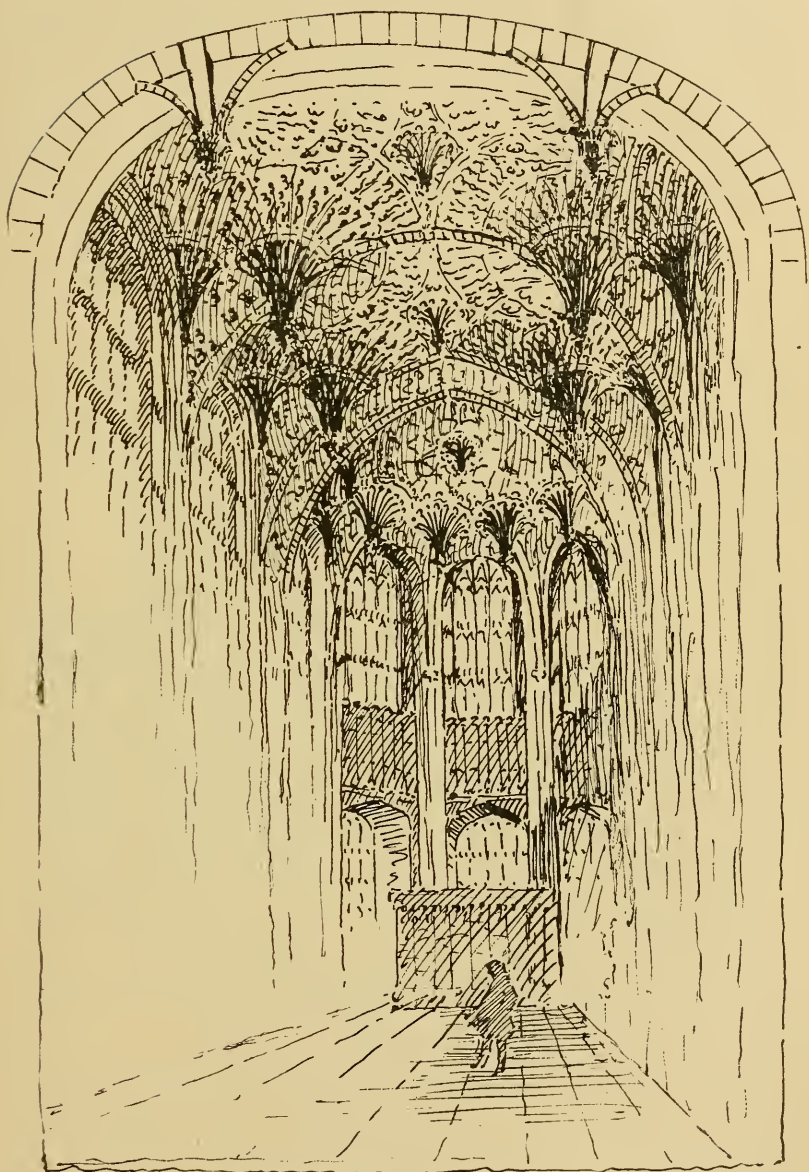


FIG. 8. FAN TRACERY.

days, exerting less thrust on the tower walls than the earlier forms.

In the absence of overhanging cornices to shelter the walls, projecting gargoyles were placed at intervals to discharge the rain water away from the walls; and their usual grotesque features suggest the unpleasant work required of them.

In this manner we may find that every portion and detail of a Gothic cathedral has its special duty, and, in performing it, gives shape and character to the style.

As Longfellow again very truly says:

"Nothing useless is, or low,
Each thing for its place is best;
And what seems but idle show
Strengthens and supports the rest."

I have said that imagination runs riot in ascribing the pointed arch to other than mechanical origin.

The most common delusion is the often expressed idea that the intricate vaulting of Gothic work was the result of efforts to imitate the interlacing branches of forest trees.

To disprove this, it is necessary only to observe that it was not until the third and last century of Gothic work that the vaultings arrived at any such intricacy, and the steps were very gradual from the plainest possible arched surfaces of the twelfth to the elaborate fan tracery of the fifteenth century, when the builders attempted, by ingenious devices, to conceal the real and true construction.

Another very plausible suggestion of the origin of the pointed arch is that such a form was produced by the intersection of interlacing semicircular arches, as was often practiced for wall decoration in Norman architecture in England.

This indeed might have suggested the *form* to those who were seeking new forms.

But there was no desire to change from the round arch, made almost sacred by its long-continued use and its religious associations. And again, the pointed arch was first employed purely for structural purposes, and in France, not in England.

Other writers, including no less an authority than Sir Christopher Wren, attribute the introduction of the pointed arch throughout Europe to the returning crusaders, who, Sir Christopher says, may have seen it used in Saracenic architecture.

In answer to this, it may be said it is very doubtful, and certainly not proven, that the pointed arch was used by the Saracens earlier than in Europe, while we do know that the round horse-shoe arch was then, as now, the common type.

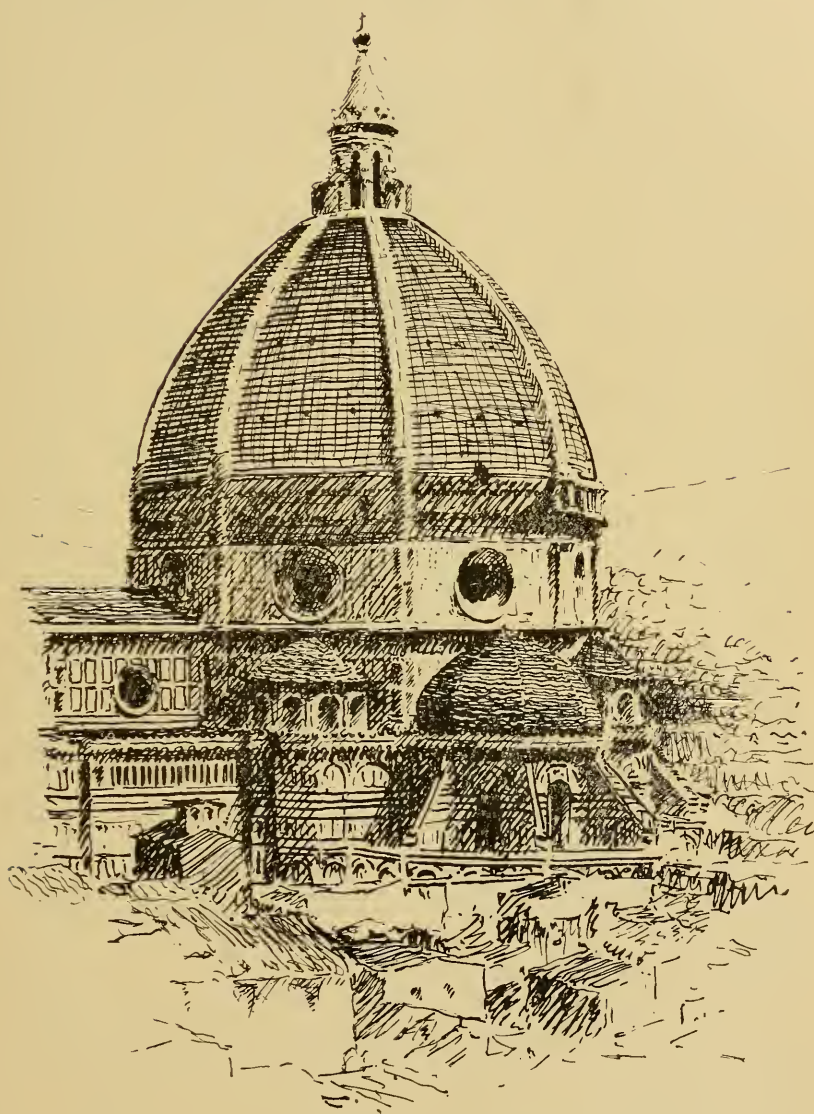


FIG. 9. DUOMO AT FLORENCE.

And, as the returning crusaders did not introduce the horse-shoe arch or any other device or ornament from the East, it is hardly possible that the pointed arch came from that source.

Others, again, have thought the lines of the pointed arch were suggested by the outline of a fish's head, because the fish forms a prominent feature in early Christian symbols.

And still others, thinking such an important feature could not have been suggested by anything "in the earth or in the waters under the earth," attribute it to Divine inspiration.

It was, in fact, such inspiration as in our day put eyes in the points of needles, and gimlet points on the ends of screws,—the inspiration we call invention, the child of necessity.

When the builders of these Gothic monuments had become so familiar with the solutions of their mechanical problems, and had expressed in stone all the structural truths they were conscious of, the spirit of adventure and novelty led them to take liberties with their materials and to produce such astonishing and indefensible features as hanging pendants and intricate fan tracery in their stone vaultings. See Fig. 8. Thus did Gothic architecture ripen and fall, and in its place no new forms arose. The attention of architects was turned toward Rome, and the illogical combinations of arch and classic orders was born again to rule the building world.

I said no new forms arose. It may properly be claimed that the lofty dome, with its lantern or cupola, which forms so conspicuous a feature of the Renaissance, and which crowns its proudest monuments, such as St. Peter's at Rome, St. Paul's at London, the French Pantheon and the Invalides at Paris, is an architectural form new to the world.

We have noticed the dome of the Pantheon at Rome, 143 feet in diameter and built about the beginning of the Christian era, also the dome of Santa Sophia, 104 feet in diameter and commenced about 527 A.D. Both of these celebrated examples were flat domes without crowning lanterns.

The first indication we have of the revival of Roman architecture is in the famous work of Brunelleschi in erecting the dome and lantern on the cathedral at Florence early in the fifteenth century. Fig 9.

This building, designed by Arnolfo, and built up to the vaultings of the nave in the Florentine Gothic style, had remained nearly a century unfinished.

The original design and model (if any were made) for covering the great central octagon, 137 feet in diameter, were lost and forgotten.

Many architects and experts were consulted, and a great variety of schemes advanced and debated.

Most of the plans contemplated a central pier or group of piers to support the roof.



FIG. 10. EIFFEL TOWER, PARIS.

When Brunelleschi, who had diligently studied the Pantheon and other works of ancient Rome, proposed his bold scheme of carrying the walls of the octagon still higher and covering it with a double shell dome, without the aid of centering or temporary supports, he was denounced on every hand as crazy, and his scheme was condemned as wholly impracticable.

After some years of discussion and agitation, he was permitted to undertake the work, which he executed with great zeal, good management and final success, although death overtook him before the lantern crowning the dome was finished. This dome at Florence furnished the model for Michael Angelo at St. Peter's, and for all modern domes in masonry.

While the Renaissance has been practiced with many variations in the civilized world for the last four hundred years, we look in vain for new architectural forms. We find only new combinations of old forms, and the question is often asked, will a radically new style ever be invented?

If my argument is correct, that the architectural styles of the past have been developed by applying the best mechanical knowledge and skill to the materials at hand in solving the structural problems presented, then it follows that new styles may be expected only with the advent of new materials, or of new structural problems to be solved. In our own day we have both of these conditions presented in certain directions, and we shall see how new architectural forms are being developed.

The new material presented to the builders of our day is metal. It is only about fifty years since iron was first considered a possible material for architectural forms.

At first it was cast in the well-known shapes of columns, arches and entablatures, and set up as hollow shams, painted and sanded to look like stone. This was not good art or good mechanical application, and therefore it could not produce a living style.

Iron and steel, however, were constantly demonstrating their worth under the hands of skillful engineers, and the proper forms for utilizing their good qualities were found to be with the wrought metal rolled into bars, rods, flanged beams, angles, etc., and put together with bolts and rivets. With this material, the mechanical engineers have solved the problem of spanning rivers and chasms that would be impossible with stone: as, for instance, some of the bold bridges across the Mississippi, the graceful suspension bridge between New York and Brooklyn, and the stupendous cantilever bridge over the Firth of Forth in Scotland, with its two spans of 1700 feet each and trusses over 300 feet high. The Eiffel Tower in Paris (Fig. 10), 1000 feet high, gives us, indeed, new architecture, but a form that will meet only a few limited conditions.

Similar applications of iron or steel to the problems of the day have given us the great clear spans of our central railroad stations, and of large buildings as in the roofed court of the Manu-

factures Building at the Columbian Exposition at Chicago, where the clear span was 380 feet and the height over 220 feet.

This naked condition of beams, bars and rods, as applied to roofs, bridges and lofty towers, is not adapted to the general problems of domestic, commercial or monumental buildings, except as an auxiliary, and in the requirements of the modern office building it is an important one.

The prime object of the modern office building is to earn the greatest possible return for its owners. This means that it must present the greatest rentable space possible on the lot, with every part well lighted and ventilated, easy of access to all parts, fire-

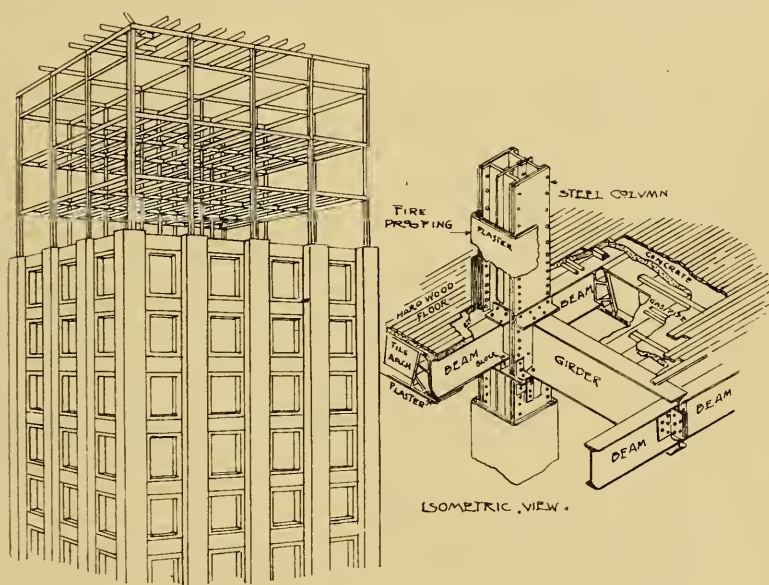


FIG. 11. MODERN OFFICE BUILDING.

proof and secure in its construction, with every modern convenience for its occupants, and with a good degree of elegance presented to those who enter it. See Fig. 11.

The attainment of this prime object has been greatly enhanced by the very modern steel skeleton construction, making buildings twenty stories high as safe and practicable as those of five stories by the old method, while the rapid-running elevators, in sufficient numbers, make the top stories as accessible as was the fourth or fifth under the old method.

Here we recognize the conditions possible for a new style, and the first important steps have been taken in some of the modern

sky-scrapers, by ignoring all historic styles, and developing the simplest possible form, as in Fig. 11, by clothing the skeleton frame with the necessary flesh and skin of brick and terra-cotta. But, as this covering skin is the old historic material, it is hardly probable that the detail or ornament applied will differ much from that with which we have been made familiar, and it remains to be seen what this age of metal will develop.

As we commenced with a style worked out in bamboo, we end with a style being developed in steel, and we may feel assured that, as every historic style has been the result of continuous application of correct principles applied to the materials and conditions imposed, modern science will work out as satisfactory solutions of its problems.

DISCUSSION.

MR. SCHULZE.—In the development of style the matter of environment is a very significant factor. I believe it is Ruskin who calls attention to the sky-line of Southern States, and compares it with the sky-line of Northern States. That thought occurred to me as Mr. Percy was showing us the drawing of that Grecian temple in the south of Italy. There were the long horizontal lines perfectly in tune and touch with nature in that country. Then, as we go north, we see the Gothic cathedral, which has an upward tendency of all the lines. Ruskin calls attention to the sky-line in the Northern States in connection with the cathedral.

I believe it is an admitted fact that environment, and particularly natural environment, has had as much to do with the development of ordinary style as the particular needs of the people with whom those styles originated.

In regard to the Leaning Tower of Pisa, I am inclined to differ with Mr. Percy in his assertion that it is the result of accident, or due to defect in construction. I have not all the facts in my mind now, but at one time I looked into the matter quite thoroughly, and, from the evidence and from the discussions that I read, everything tended to show that it was not the result of accident, but of deliberation.

MR. MANSON.—Can Mr. Percy tell us the origin of the onion-shaped dome that we see so much in Russian and Turkish pictures? It exists to a large extent in Russian cities, and particularly Moscow.

MR. PERCY.—I do not know the origin of that.

MR. WAGONER.—What did the architect rely upon to relieve the thrust of the dome in Florence?

MR. PERCY.—Aside from the thickness of the walls, which is

about 15 feet, there are two hoops or bands. The two hoops are made of timber, with iron straps at the angles. The dome is not circular, but octagonal in plan. All the other modern domes, or nearly all (such as St. Peter's, which was the first great dome after Florence), are circular. In St. Peter's the iron hoops were put around the inner dome at the time it was built, and others have since been put around the outer dome. This was done because there was some danger of its spreading. Some of the iron bands have been broken. The thrust of these domes is comparatively small. The construction is such as to reduce the thrust to the lowest possible amount. The shell is made as light as was in those days considered prudent, although I have no doubt that in our day we would not use more than half the amount of masonry. The inner wall is about 5 feet thick. The architect, in building the dome, employed methods that made it possible to build it without any centering to support it while being built. Of course it is evident to every one that a horizontal ring, once completed, would support itself. It was built so that the courses of the joints were all vertical. In the lower portion there were long and short stones used, and, when a ring was completed, every alternate stone stood up half its length above the others. After that long stones of the same length were used, and they remained in place because the center of gravity was supported. You will understand that every course presented the appearance of a beveled tooth-gear wheel, and in that way the dome was carried to completion without centering.

MR. SCHULZE.—A rather interesting story occurs to my mind in connection with that dome at Florence. An artist living there, by the name of Ghiberti, afterwards became famous for the gates that he designed for this same building. He was not an architect. The dome was not completed, and, from what I can gather, the architect, Brunelleschi, enjoyed less of the confidence of the people than did Ghiberti. The result was that they were both appointed to complete the dome. In the course of their joint labors jealousies arose. Brunelleschi soon discovered that Ghiberti was utterly incapable of carrying on the work, and yet he was getting more than his share of the credit. This irritated Brunelleschi to such an extent that he wanted to get out of that rather awkward partnership. He felt that he deserved to have all of the credit. But the difficulty was, how to get out of it. One morning he feigned sickness, and the result was that Ghiberti had to take charge of the work. The progress was very slow that day. Brunelleschi continued to feign sickness, and the citizens of Florence soon dis-

covered that Ghiberti was not the man for that position, and Brunelleschi was appointed to continue the work alone.

MR. PERCY.—I remember reading that story, and, if I remember correctly, this occurred at the critical time of constructing the timber hoop that I mentioned. Ghiberti did not know how to go to work at it, and Brunelleschi continued his pretended sickness until it was discovered that Ghiberti had no ability for carrying on the work, and then Brunelleschi was relieved of the unpleasant partnership. Up to that time each had equal salaries and equal credit.

MR. HENNY.—You have referred to Chinese architecture as dealing with bamboo structures. Are there any other buildings besides bamboo? Are there stone or brick buildings?

MR. PERCY.—There are stone buildings. The Japanese and the Chinese do not differ much from other nations, so far as I can see. It is the peculiar forms that I selected for my paper—the curved roof and light bracket construction, as shown in their pagodas, houses and other works of that kind—which give the peculiarities to Chinese and Japanese forms. Their mason work is substantial, and they use the stone quite naturally. Where they have basaltic rock, they usually build it up much the same as other people do, and where they have stratified material they build it in courses, the same as others do. All people have taken the most practical way. The stratified material is laid up in courses, and the basaltic material, broken into many-sided forms, is laid up accordingly. In the paper my idea was to bring out the striking forms or outlines, or that which gives character to architecture. I was in hopes there would be a more lively discussion in the direction that Mr. Schulze pointed out. I know that many writers attribute all those things to the natural surroundings and environment, and to other influences of that character. I question this in my paper. Take the illustration that Mr. Schulze presented of the flat Italian styles as compared with the great pointed roofs of more northern Europe. Italy is more like California than any other section of Europe. I have traveled through the great valley of the Po. There the mountains rise on each side, very similar to our own San Joaquin Valley, only the mountains are not so large as the Sierra Nevadas on one side and the Coast Range on the other. It is the great central valley of Italy. Amid such surroundings there is that flat style of Italian architecture, while in Central France, where Gothic architecture developed first and where it attained its greatest perfection, you cannot see a mountain, you do not see sharp peaks. Take the Cologne Cathedral;

you may photograph it on all sides and no mountains will be shown. So with all those great cathedrals, with their tall spires, in Central France there are no mountains to be seen, while there is hardly a city in Italy from which distant mountains are not visible. In Florence and in many Italian cities you can go upon high hills and look down upon the city.

So I do not think that environment has very much to do with the architectural forms. They have developed along the lines that I have pointed out in the paper. I must therefore disagree with Ruskin, for whose opinion I once had very much more respect than I have now.

As to the Leaning Tower of Pisa and other leaning towers, I have read various arguments about them, and especially those of Mr. Wm. H. Goodyear. He has made a most remarkable investigation of the irregularities in Italian buildings, and in many striking cases he attributes it to some deep-laid scheme to produce optical effects. He has shown great ingenuity in making his claims. When I visited the Leaning Tower of Pisa it seemed to me that I could tell from the inside of the building why it was in that condition, from ordinary, natural causes. There were cracks in the walls, and every indication that the building had settled in a way that threw it out of plumb. The cracks are just where you would expect to find them in a building that had settled and was in the position of this tower.

The architects in this country find that it is not an easy thing to build campaniles and lofty towers on soft ground and have them stand vertical. The campanile of the "New Old South Church" in Boston leans a foot or more, but the architects did not intend it should. These lofty campaniles in Italy are nearly always built on alluvial soil, and apparently without finding a good, solid bottom. The Leaning Tower of Pisa is built on soft ground. I have the authority of a French architect, who claims to have dug down and investigated the foundation, that he found it built on piles. To build a lofty, cylindrical monument, and have it stand vertical as against any pressure and various disturbing causes, is much more difficult than the erection of buildings that have a broad base. In nearly all the Italian cities the lofty campaniles are out of plumb. There are other leaning towers besides that of Pisa. There is one at Bologna that is not more than two-thirds as high and which leans over ten feet.

The articles that have been published by Mr. Goodyear in our journals are very interesting reading indeed, and one must admire his ingenuity, however much they may differ from him in his con-

clusions. In nearly every case he attributes the irregularities to some desire on the part of the builder to produce some pleasing illusion, and he often gives some very plausible reasons for it; but the reasons are not always the same—that is, the irregularities may be in one case directly contrary to the one in the other, and yet a similar effect is sought, in his estimation.

MR. WAGONER.—What influence, if any, upon architecture, did the invention of window glass have? That is, did it modify the style in any manner?

MR. PERCY.—There is no doubt that glass has had its effect, but, in the first place, the date of the invention of window glass is hard to fix. Fragments of window glass have been found (and I have seen this myself) in the ruins of Pompeii. Glass was used to some extent in the time of Christ, but it was not common. The great development of glass, and of windows glazed with glass, came with Gothic architecture. It can now be very readily seen that Gothic architecture is planned to allow enormous windows. At first plain glass was used. The use of colored glass naturally shut off a great deal of the light, and therefore, to get sufficient light with stained windows, it was necessary to make them as large as practicable.

We may be sure that in northern latitudes, before the use of window glass, the window openings were small, on account of the cold, but were larger in southern latitudes, where it was warmer. With the invention of glass it was very natural that the window openings would become much larger. In the period of Gothic church building this was carried to the greatest extent, and painting the glass became an ornamental feature. Before that, in the Romanesque period, the walls were decorated with paintings, but in Gothic architecture there were no walls to decorate, and the decoration was put into the windows. In one case, the great wall surface was painted; in the other, the great window surface was decorated.

STREET RAILWAY TRACK CONSTRUCTION.

BY M. D. BURKE, MEMBER OF THE ENGINEERS' CLUB OF CINCINNATI.

[Read before the Club, February 16, 1899.*]

THE title selected for this paper was requested before the paper was written, and was made sufficiently broad to include anything pertaining to street car tracks. But the writer wishes to announce at the outset that the essay will not be an exhaustive one upon so broad a subject, and will treat upon but two or three features pertaining to such work, the only excuse for selecting such a title being that those features are of rather a general nature. No mention will be made of the topics which have been so frequently and ably described heretofore.

In treating the subject, it appears to be desirable to describe briefly what was done in the days of the horse car, the transition to that which is now being done to provide tracks for the motors at present in use, and, finally, to suggest such forms of construction as would appear appropriate for the conditions which exist, or are likely to prevail in the near future.

More than twenty-seven years ago the writer was employed to reconstruct certain portions of track in Cincinnati, and to replace some curves that were in unsatisfactory condition. He found that the curved rails were iron castings, and that the curved tracks had been constructed as shown by Fig. 1. Only the inside rail was provided with a guard, which was unnecessarily high, the groove was excessively wide, while the outer rail was merely a flat casting upon which the wheel was carried upon its flange. It was thought possible to better some of these conditions, so new patterns were made, and the curved tracks were built as shown by Fig. 2. It will be observed that the "knees," or castings which were intended to hold the timbers to gauge were omitted, and the tie rod introduced, and that both rails were grooved. Prior to that time, these little cast brackets, fastened to the ties with three-inch spikes, had been the sole dependence for holding the track to gauge, and, since the loads were always carried upon the upper outer corners of the timbers, there was always a tendency to widen the gauge. The tie rod was introduced to resist this pressure, and "knees" were afterwards used only where required for straightening crooked stringers, or where joints needed a special support.

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This was the first track which the writer ever saw made of grooved rails. This form of rail, somewhat lighter in section, was, at about that time, or soon after, patented, made of rolled steel, bent to the desired radius, and, for many years, was manufactured and sold by the William Wharton, Jr., Company, Limited, of Philadelphia, as the Wharton Patent Curve. The form of rail head has

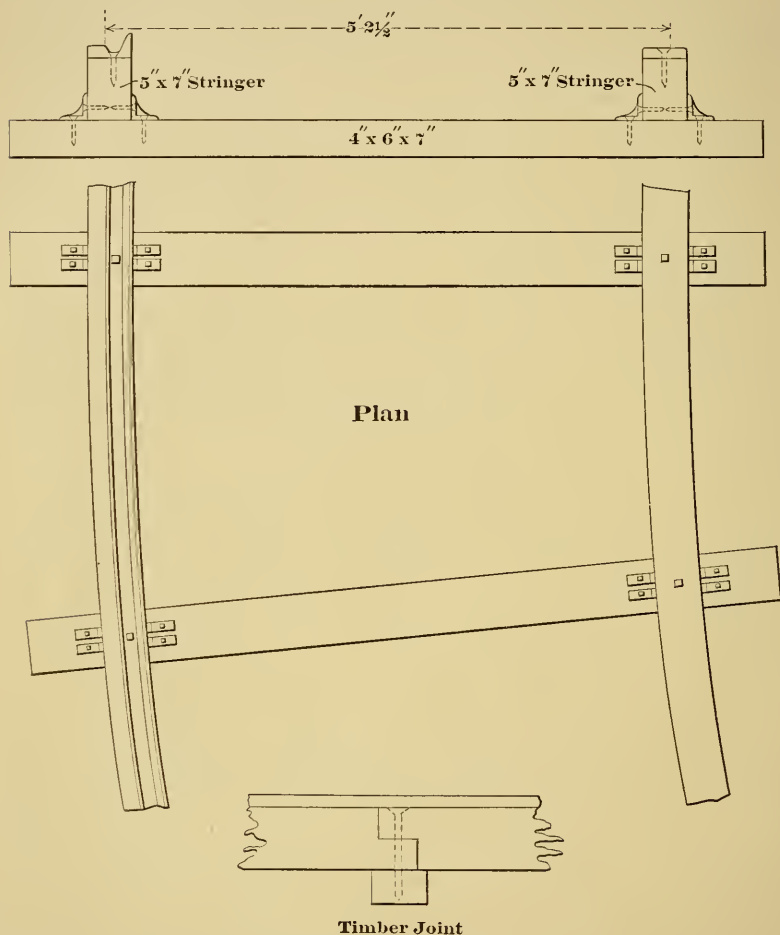


FIG. 1. PLAN AND SECTION OF CURVED TRACK AS BUILT PRIOR TO 1871.

not been essentially changed in the standard grooved rails of to-day, but the support is different.

In those days street railroad rails were essentially "strap rails," varying in weight from about 18 pounds to 50 pounds per yard. They were spiked to the tops of wooden stringers, which were in turn, fastened to cross-ties, generally with boat spikes, but some-

times with treenails or wooden pins. The earth or gravel was tamped under both the longitudinal stringers and the ties, which were placed four or five feet apart, so that the loads carried, at the speeds then attained, were fairly well supported, while the track was in good condition. But there was an abundance of elasticity, and the "wave motion" that theoretically precedes the locomotive, was generally visible to the naked eye. Each car was usually provided with a "frog," by the use of which the driver was ex-

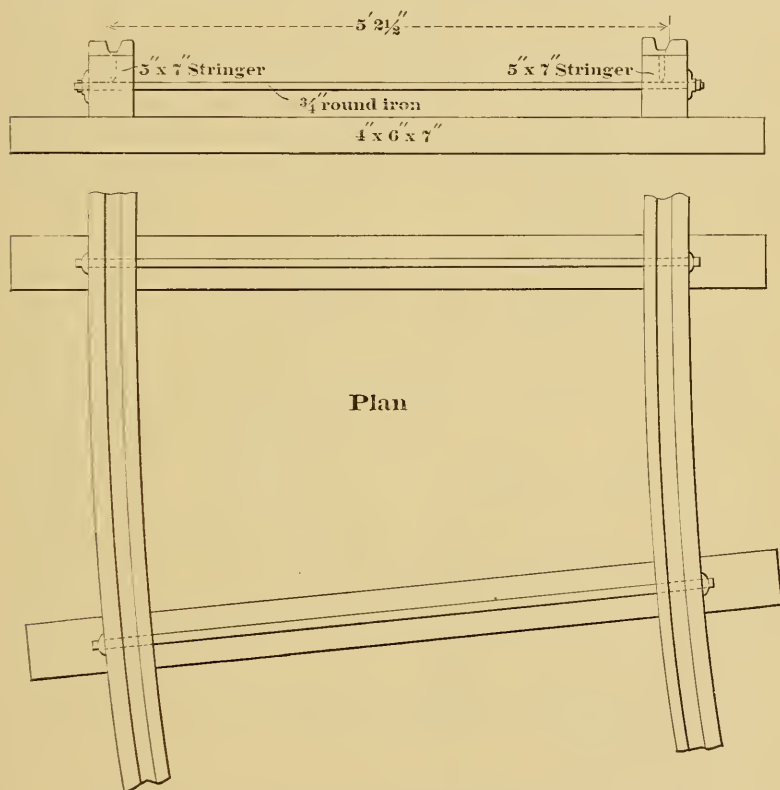


FIG. 2. PLAN AND SECTION OF CURVED TRACK BUILT IN 1873.

pected to be able to pull his car onto the track, if it got off, or to pull it off and on again, if it became necessary to pass around some immovable obstacle on the track.

The municipal statesmen of those days, in protecting the rights of their constituents, found it necessary to provide a broad inside tram, so that the street car track became a tramway for the use of all vehicles that could travel upon it. The width of the express wagon, to the outside of wheel treads, was found to be about five feet two inches, so the gauge of street car tracks was generally

fixed at five feet two and a half inches, and ordinances provided that the rails should have an inside tram of three inches. As a natural result, vehicular traffic was concentrated along the lines of street railroad tracks, and where double tracks existed was systematized by them to some extent, but vehicles going in the same direction did not travel at the same speed, and the pulling into and out from the tramways was destructive to pavements and tracks as well as to vehicles.

The rails were secured to the stringers by spikes having countersunk heads, driven through the tram of the rails into the wooden stringers, but the expansion and contraction of the rails, due to changes in temperature, either sheared the spike heads, enlarged the spike holes, or bruised away the wood, and the fastening became defective, but the rails were provided with lips coming down over the corners of the stringers which aided greatly in keeping them in place.

Pavements were generally of cobblestone, or the roads were made of broken stone or gravel. Between rails, where the car horses or mules traveled, the most satisfactory roadway was the cobblestone pavement. An eminent engineer of this city invented, and, I think, patented, the pavement made of round locust blocks paved on end. One of our prominent street railroad officials declared that the said engineer made that pavement all out of his own head, and had blocks left. In the tracks it was an utter abomination, as the heart of the locust block polished and became worn to a rounded point, while the residue of the stick disappeared, and animals' feet were destroyed in traveling on the slippery pegs. Where the wooden block is of about uniform density, as cedar, oak, or pine, it does fairly well; but if the traffic is confined to the narrow paths defined for street car horses, it soon becomes worn and does not furnish as reliable and durable footing as the much-abused cobblestone.

A few forms of rails that were used are shown in Fig. 3. "A" shows the "crescent rail," which was laid on Elm street. It weighed about 18 pounds per yard, was spiked, or rather nailed to 3 x 6-inch stringers, had no inside tram, and was rather justly criticised. "B" shows the Route 9 rail, which was laid on Vine street. It weighed about 30 pounds per yard, the rail head being rolled thin to fit over an oak strip, nailed to the top of the stringer. It had the required inside tram, and, if it did not fill all of the requirements, it rattled around in them effectually. "C" was the Mount Auburn, or Route 8 rail, laid on Main street. It was laid on 6 x 8-inch timbers placed flat. It made a very good tramway,

but a rather indifferent car track. There was but little rail head, and what there was rested upon the extreme outside of a broad timber, and was so soon pressed out of gauge that the cars traveled upon the wheel flanges. "D" was used upon the same route, on the upper end of Main street. It was laid on 4 x 6-inch timbers, set on edge. There was much criticism because of the narrow inside tram, but the track, being held to gauge by tie rods, was a fairly good one for street cars.

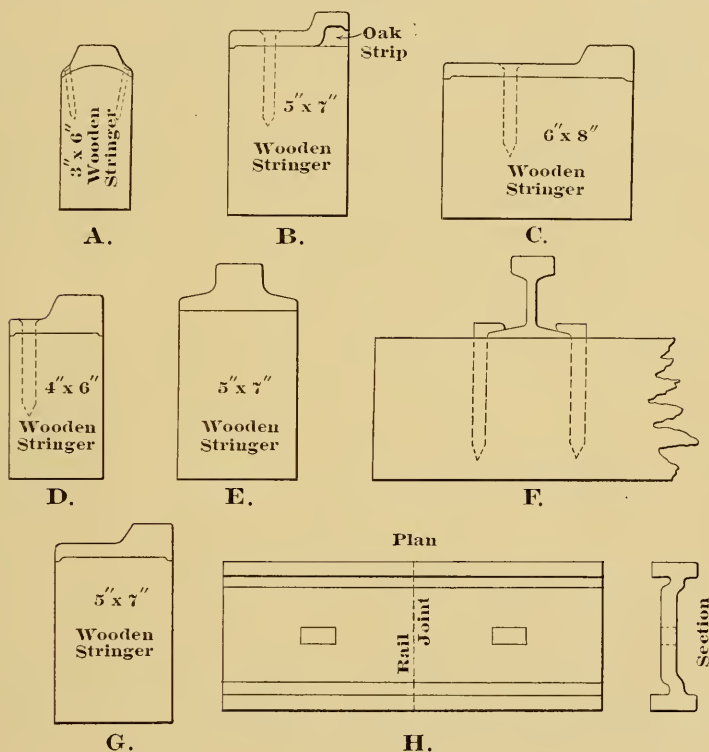


FIG. 3.

"E" is the center bearing or "saddlebags" rail, laid on the eastern part of Route 5, and on Route 7. It was the best of the strap rails, because it had sufficient weight to make it tolerably rigid, and, as it brought the weight upon the center of the timber, it avoided the tendency to tilt the stick over, and thus widen the gauge, as did all of the forms having the inside tram. The lack of the tram brought upon it much censure from teamsters, but it was retained until the advent of the electric motor.

"F" is the standard "T" rail of about 35 to 40 pounds per

yard, always preferred by railroad companies, and very much used, but objected to in pavements, because it provided no tram, but did provide a groove alongside of it in the road. Its defects, from the side of the railroad company, were lack of depth, lack of protection to wheel flanges, and weak joints; while, on the side of the public, it was claimed that no street surface could be maintained adjacent to it.

"G" is the standard tram rail, weighing from 42 to 50 pounds per yard, used upon what was regarded as first-class lines in cities requiring good service and well-maintained streets.

Where the rails met upon the timbers, the wood soon yielded, and the maintenance of the joints became troublesome. In original construction an iron plate about $4 \times 6 \times \frac{1}{4}$ inches thick was used, but it was soon shown that something more rigid was necessary. The cast iron joint plate, shown in plan and section at "H," Fig. 3, was devised by the writer, and was the most satisfactory that he has seen, excepting a plate slightly lighter, but very similar in section, made of rolled iron.

The gauge having been arbitrarily fixed at a width that suited street traffic, it became necessary to construct cars having a short wheel base in order to operate them on the curves necessary to turn the corners in city streets. A rigid wheel base of about six feet was commonly adopted, and we could swing around a circle having a radius of 33 feet to the center of the track. As might be expected, there was some friction connected with such proceedings, but these short curves never occurred upon heavy gradients, and the resistance due to curvature was not the most serious obstacle to be surmounted.

For the empty horse car, the load upon each wheel was about half a ton, seldom exceeding 1200 pounds. The *live* load was exceedingly variable, and generally, good-natured and accommodating. If it found itself off the track, and stuck in a chuck hole, it would often get off and assist in putting the dead load back upon the track. Of average passengers, it takes between fifty and sixty to make a load of four tons, but that load was often exceeded on crowded cars, making the weight on each wheel frequently greater than one and a half tons. These heavy loads, on the yielding timbers, disturbed the pavements, and made street and track repairs continuously expensive. City officers learned that the maintenance of streets carrying car tracks was more expensive than that of other streets, and they began to lay additional burdens on the street car companies. Promoters, failing to realize the great expense incident to street maintenance, frequently accepted grants

which involved such great expense for paving and maintenance, that the conditions of the grants could hardly be complied with. The stringers required such frequent renewals, and the rails were so constantly loose and out of gauge, that some remedy must be devised.

Mr. Johnson had invented an automatic switch, so planned that the mule should turn it by stepping on the proper side of a tilting plate, and thus avoid interrupting the driver when engaged in his legitimate occupation of beating his team. In the few nights that the writer spent with the inventor in this city, setting two or three of those contrivances, Mr. Johnson saw the decayed timbers, and, bringing his inventive mind to bear, he produced the "girder rail." The iron or steel stem and base of the "T" rail were placed beneath the head and tram of the strap rail, the base and stem taking the place of the wooden stringer. Being about right, it soon became popular, and the worst evil now connected with it



FIG. 4.

arises from the fact that there are too many forms of it. If standard weights and heights were rolled, the cost of manufacture could be reduced, and better results would follow.

Street railroad companies had become accustomed to the use of light rail sections, the price per ton for iron rails was then about three times the present price for steel rails, the requirement for the inside tram was being rigidly enforced, and the sections produced were influenced by these conditions, so that all defects were not eliminated. In Fig. 4, "A" is a typical section of light girder rail, weighing about 32 pounds per yard, while "B," would then, (say fifteen years ago), have been regarded as a standard heavy section.

In these sections the lack of strength in the joints is at once apparent, and lack of depth became troublesome so soon as any proper form of street pavement was to be placed along the tracks. They have still another defect which people were slow to learn, and which, in fact, is still a mystery to some people who are strug-

gling with low joints. In the girder, the rail head and tram constitute the upper chord, the base of the rail the lower chord, while the stem makes the connecting web. The distribution of the material is approximately as follows: 66 per cent. in the upper chord, 21 per cent. in the lower chord, and 13 per cent. in the web. This is a bad disposition for a beam or girder, especially when the material in the upper chord is subject to much wider and more sudden variations in temperature, than that in the lower chord. The rail head and tram, being exposed to the direct rays of the sun, become much warmer than the base of the rail, and consequently longer; there is sufficient material in the base to cause the rail to curve vertically, loosening it from the ties, and no fish plate or other fastening, and no trackmen, however skillful, can keep up the joints. This condition, with its consequent troubles, still exists with the forms of rails having the inside tram.

When cities began laying stone block pavements, and it became apparent that neither broken stone, gravel, nor asphalt, could be maintained where the top of the tie came within three or four inches of the surface, various devices were brought out for lowering the ties. The "clamp chair," which was especially adapted to what is known as the "bulb rail," in which the lower chord of the girder is given a rounded form, the "box joint chair," the "brace joint chair," and numerous "rail clips" and "tie plates" have been devised, and many are still in use; but those girder rails still keep on bowing up in the middle and down at the ends, and they still continue to loosen any and all of those fastenings, and they are not likely to stop, so long as metals continue to expand when heated.

To obviate these difficulties, and to provide for the greater weights and higher speeds of electric motors, deeper girders are being generally adopted, carrying the rail down on a broader base to a heavier tie, placed at a greater depth. Sixty-five and 70 pounds per yard, are now regarded as light rail sections, while 80, 90, 95, and even 100 pounds per yard, are now common weights of rails used in the tracks of electric roads in the streets of our larger cities. But nearly all of them are laid on wooden ties. It is true that the tie is generally imbedded in concrete, or placed upon a foundation of crushed stone compacted by rolling, but the fastening of the rail is to this perishable tie, and it is inaccessible, except by the digging up of costly pavements, and the interruption of congested traffic. The stringer has gone, now why not eliminate the perishing tie. Leave off that silly inside tram, and omit the wooden tie, and you may be able to make your track for electric roads reasonably permanent.

The maintenance of the street railroad track is essentially different from that of the steam railroad track; and in its construction this difference should be fully considered.

The steam railroad track is placed upon a right of way owned and controlled by the company which owns the track. Its construction, its drainage and its maintenance, are all in the hands of its owners, who supply the requisite material, and direct the workmen under skilled supervision. The joints, the drains, the ties, are visible, and are subject to daily inspection. When the requisitions have been made, and the materials and funds supplied, (it may be that these are sometimes administered in homeopathic doses), there is nobody to consult, no traffic to interrupt but that

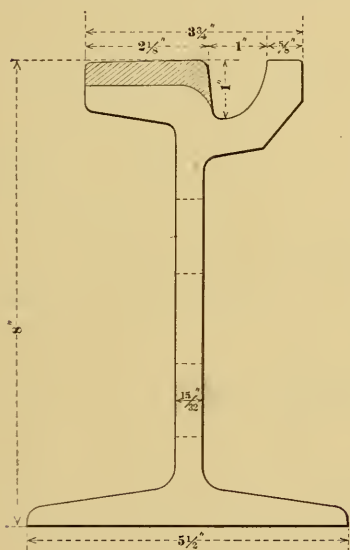


FIG. 5.

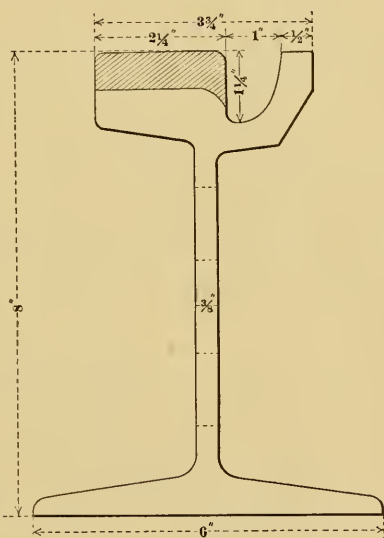


FIG. 6.

controlled by the company itself, and repairs are systematically made, without interference or delay.

With the street car track, these conditions are all reversed. The roads are built in public streets or highways, where everybody has a right of way, and each individual assumes and asserts that he has a little better right than any street car company, when he wants to drive on the street, and an absolute right to be carried on time, when he wants to ride on the cars, he preparing his own schedule.

The track construction is entirely buried from sight, excepting the tops of the rails, and frequently they are covered with

mud. The drainage, when there is any, is under the control of municipal authority, and, unless provided when the tracks were laid, it cannot be either supplied or maintained by the street railroad company, unless it be under conditions which the municipality shall dictate. If bolts or spikes become loosened, or a tie requires better support, such facts cannot be known until a depression is visible in the track, and the adjacent pavement shows the effect of the movement that has been imparted to the rails. Then a permit must be obtained from the authority having control of street repairs, often involving the rights of contractors who have agreed to maintain the pavements, and in due time the street pavement can be taken up, the defect remedied, and the pavement replaced. The delays are so vexatious, and the conditions imposed are so onerous, that what might have been prevented at trifling cost by the tamping of a single tie, or the adjustment of a single joint, has involved numerous delays, and the expenditure of many dollars.

Because these conditions do exist, and for the further reason that street railroad companies should, as a matter of right, use every proper means to render their service as prompt and reliable as it can practically be made, and because the use and occupancy of streets and highways by the street car companies should be attended by the least disturbance of such roadways, and the least amount of interference with their use by the general public, it follows that the construction of street railroad tracks should be of the most durable materials, and the most permanent workmanship that is attainable at reasonable cost. Since the electric motor has taken the place of animal power in propelling cars, and since those cars have been given such weights and speeds that colliding with them is accompanied with great danger, it follows that no tramway should be provided to allure vehicles to their tracks, but that street surfaces should be so formed that wagons will pass over or along the rails without being impeded by the broad groove or rut that invariably accompanies the inside tram. That feature should, therefore, be eliminated from the rail. Where street surfaces are properly paved and maintained, the full grooved rail should be laid. Where they are composed of broken stone or gravel, the deep "T" rail should be laid, having a low inside guard that will provide a space for wheel flanges, and a shoulder against which the road metal can be packed.

Possibly a digression may be permitted for a brief discussion of rail sections. It may be true that some of the sections of girder rails now in the market, have been designed by the men who manufacture and sell steel by the ton, so that weight is fully as desirable

as length of service. Then it may be true that electrical engineers have designed some sections, without having made a careful study of the matter of so disposing the material as to secure the greatest life of rail at the least cost. And then again it is possible that a few city engineers have interjected certain requirements and con-

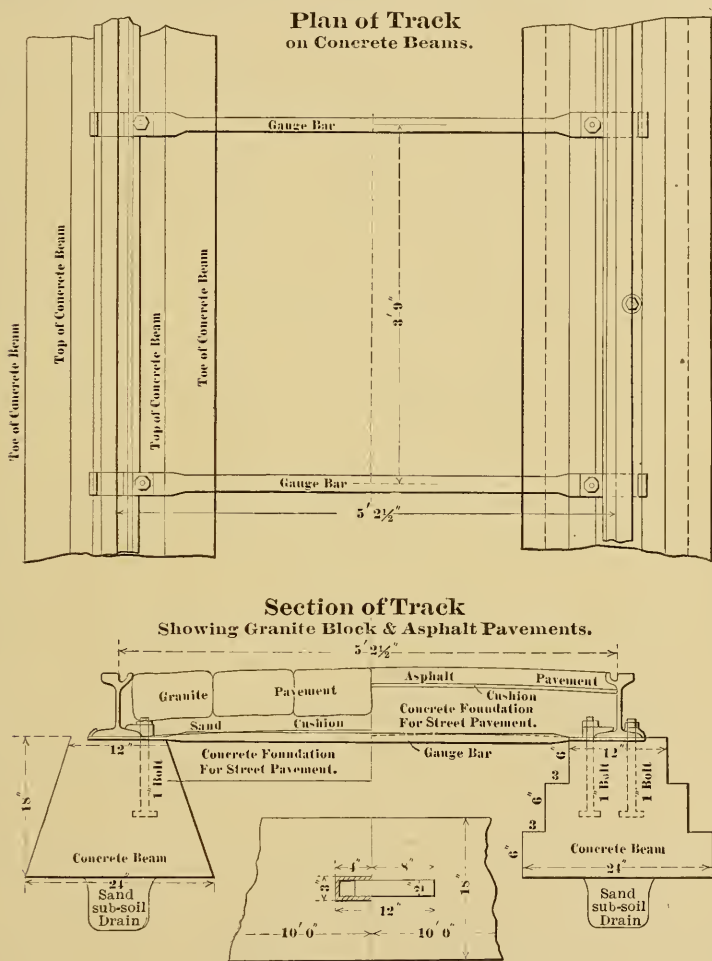


FIG. 7.

ditions, just because they could. At any rate, there is great variety, and many of the sections are not such as can be commended on the score of economy. It is not the purpose of the writer to design a rail, but he is willing to state a few of the principles that, in his judgment, should be considered in making such

a design, and he desires to urge the advisability of adopting standard sections for certain heights and weights, so that the cost of manufacture can be reduced.

In track construction, it may be assumed that the rail is the essential feature, and that it should be so designed that it can be rigidly held in place, that it will resist, without deflecting perceptibly in any direction, the stresses to which it is subjected, and that it will continue to do so until it shall have lost, by actual wear in service, the greatest allowable percentage from that portion with which the wheels come in contact, before it shall be unfitted for service. The rail head upon which the wheels bear, is the only portion subjected to actual wear, and when that shall have lost so much material in service as to cause it to fail to properly support the car wheels, the whole of the residue of the rail becomes scrap. The web and the base serve only to maintain the rail head in proper position. Width of base renders the rail laterally stiff and easy to support. Depth of rail makes it vertically rigid, and carries the rail fastenings down beneath the paving blocks. It also provides space for rigid joint fastenings.

When the rail acts as a girder, the material in the base is subjected to tensile stress, and that in the rail head to compression. To allow for reasonable wear, there should be at least one-third more material in the upper chord, or rail head, than there is in the lower chord or base. In the web there should be sufficient material to transmit the loads to the base. Inasmuch as the web must resist lateral as well as vertical stresses, it is usual to make rather liberal allowances for that purpose, and also to give ample bearing surface for the bolts, but web material, beyond that which is required for these purposes, is wasted, and, adding to the thickness of the web, in high rails, increases the weight more rapidly than increasing any other dimension. It is here that waste occurs. Granite blocks constitute our heaviest pavements. They are 6 inches in depth. There cannot, therefore, be any valid reason for giving rails a greater depth than 8 inches. In a rail having a depth of 8 inches, there can be no possible use for a greater thickness of web than $\frac{3}{8}$ inch. By no calculation or practical experiment can it be shown that a web of that thickness could be deformed by any force, or combination of forces, acting upon it in the track.

As an example, take Section 95, No. 216, as rolled by the Johnson Company, and very extensively used in this city. Fig. 5 shows the rail as used, the shaded portion of the head being that part subject to wear, and Fig. 6 shows a rail of the same weight

and height, just as rigid and strong, the shaded portion of the head again representing the part subject to wear. When that part shall have been worn from either rail, as it will be by continued use, the residue will be scrap. A comparison of the areas of the shaded portions of the sections shows that, if the wear be uniform, the changes suggested would increase the life of the rail about 60 per cent. That is to say, if the rail shown in Fig. 5 has a life of fifteen years, that shown in Fig. 6 will wear, under the same traffic, twenty-four years or more.

The essential differences consist in widening the base, deepening the groove by lowering the guard, squaring up the side of the rail head to lessen the flange friction, and taking material from the web and placing it where it will be subject to wear. But this is only a criticism, not a design. It is made upon a rail section which is very familiar to all of us, and is in fact on a section that is very much superior to many that are in use. The tonnage carried by some of the tracks where this rail is in use closely approximates, if indeed it does not exceed, that upon the main tracks of some first-class steam railroads. That use will wear down those rails, and, unless the joints fail, the wear will be quite uniform, and nearly as indicated upon the sections. It is certainly desirable to defer the day of renewal as long as possible. It is no more difficult to roll one of these forms than the other, and that form should be used which, at equal cost, has the longest life. But it is time to speak of the real subject of the paper, that is, how to lay the rails.

In *Engineering News* for January 5, 1899, are two articles and two designs for "permanent ways" for steam railroads. The one written by a member of the editorial staff of that journal is so readily adaptable to the construction of electric street railway tracks that its author should have full credit for the invention, if there be one. With the modifications which the writer would suggest, to adapt it to street railroad tracks, it is shown in Fig. 7.

The plan consists essentially in placing the rails directly upon continuous concrete beams, placed centrally under each rail, fastening the rails to the concrete by holding-down bolts and rail clips, and holding the rails to gauge by gauge bars. There is nothing perishable in the construction, and, when properly built, there should be no expense for track repairs until the rails wear out. The dimensions of the beams that are necessary, will depend upon the nature of the soil and upon the climate in which the tracks are laid. In the average clay or gravel soils of this vicinity, the dimensions shown on the drawing will be found ample to sustain the heaviest traffic, where the subsoil is properly drained. This

form of construction should not be used upon newly constructed embankments subject to any considerable settlement.

The concrete can be made in its proper position in the street, or the blocks can be made at a factory, hauled to the work and placed in the tracks, being connected by iron dowels, as shown in the sketch. If made in position, the concrete would be placed in three layers, and the sides, instead of being sloping as shown on the left in the drawing, would exhibit offsets, as on the right. The sectional area and the bearing surfaces are the same in either case. The writer, having much more faith in the continuous beam than in either the tamping of the foundation or the dowel joint, would, wherever possible, build the beams in position; but where that process would be impracticable, the other method could be successfully used, and it would have some advantages. For instance, there could be no question about the quality of the concrete, and it could not be used until it had acquired sufficient strength to insure its preservation.

The base of the rail should be about six inches in width, and its depth should be sufficient to give to the rail joints as nearly the sustaining power of the body of the rail as is practicable. If made in position, a bearing plate should be placed under rail joints; if made at the factory, that would not be found practicable. By the plan shown in *Engineering News*, the holding-down bolts are all shown on the inside of the rails, but, for a street car track, the writer would place two bolts in each rail upon the outside, and bring those bolts through the base of the rail, for the reason that the paving may be all taken from one side of a rail, while it remains upon the opposite side, and the pressure might then be so great as to spring the rail inwards, unless the rail clips had very efficient bearings. While such motion would not be likely to be imparted to the rail, the method suggested would certainly prevent it. But there is still another reason,—viz, these two bolts, passing through the base of the rail, would prevent any creeping of the rails; and, as the holes need not be slotted, the expansion and contraction of each rail, whatever that might be, would be confined to that rail length, and its effects could not become cumulative. About one-half the usual allowance for expansion and contraction should be made in track laying, as that would prevent any objectionable openings at the joints, and at the same time avoid subjecting the track fastenings to the extreme stresses brought upon them by attempts to wholly resist such motion.

The quality of the concrete, used in these beams, is an essential feature. Its cost will vary, in different localities, with the cost

of the materials which compose it. In this climate it is not essential that it be made with Portland cement, because it will not be exposed to the direct action of the weather; but, if natural cement be used, it must be of good quality, and the ingredients must be so proportioned and manipulated that the resulting mass will be a dense artificial stone. In this locality, or wherever clean sand, crushed stone or clean gravel is obtainable at the prices prevailing here, it can be made, at a reasonable profit, at \$5 per cubic yard. Upon this assumption, let us see what a mile of this kind of construction will cost, omitting the rails and street paving, as those items are common to each kind of track.

Estimated cost of one mile of permanent way for electric street railroad:

1360 cubic yards of excavation at \$0.20 per yd.....	\$260.00
120 cubic yards of sand for subsoil drain at \$1.00 per yd.....	120.00
880 cubic yards of concrete at \$5.00 per yd.....	4,400.00
9665 pounds of holding-down bolts, with heads and nuts, at \$0.01½ per lb.....	144.98
32,553 pounds of gauge bars (6'-1" x 3" x ¾") at \$0.012 per lb.....	390.64
2816 rail clips at \$0.04 each.....	112.64
7089 pounds of joint plates at \$0.012 per lb.....	85.07
Total	\$5,513.33

or \$1.04 per lineal foot. If the blocks be made in 10-foot sections and connected by dowels, the joint plates should be deducted, and \$253.00 added for the cost of dowels and sockets, making the total cost per mile \$5681.26, or nearly \$1.08 per lineal foot. The cost of the track laying may be assumed to be the same as that for the present form of construction. Since it would necessarily be done simultaneously with the placing of the concrete, the actual expense would probably be somewhat less.

Estimated cost of one mile of street railroad track on ties in concrete:

1400 cubic yards of excavation at \$0.20 per yd.....	\$280.00
1175 cubic yards of concrete at \$3.00 per yd.....	3,525.00
2640 ties at \$0.45 each.....	1,188.00
7920 pounds of spikes at \$0.0125 per lb.....	99.00
4693 square yards of rolling at \$0.03 per sq. yd.....	130.79
Total	\$5,222.79

or, about \$0.99 per lineal foot. If the ties be laid on broken stone, the cost per mile will be about \$3850.00, or about \$0.73 per lineal foot.

From these figures it will be seen that, if this form of track construction be desirable, its cost is not prohibitive, for in one

case the saving, by methods now in common use, is but 5 cents per foot, or \$264.00 per mile, and, in the other, the saving is but 31 cents per foot, or \$1636.80 per mile. Now, is it desirable? If it be really permanent, there can be but one answer to the question, and it appears to be perfectly self-evident that a track, properly constructed upon the plan suggested, would cost practically nothing for repairs until the rails should fail from actual wear. Being continuously supported, the rails would not act as girders, but, if the foundation should yield, or be dug from under them, those concrete beams and the rails would carry any electric car now in use over spans of ten or twelve feet without perceptible deflection. The construction does not extend into the ground a sufficient depth to interfere with pipes or other conduits, and at the same time it does rest upon a part of the street that is not likely to be seriously disturbed by the plumber or the street repairer.

The question may be asked, why make the beams so heavy, when the loads upon them are so light? The answer is, that in view of the great amount and unknown position of the excavations that are almost constantly being made in the public streets, it is cheaper to provide a wide margin of safety than to repair the defects that might result from such causes. Then, as we know by recent experience, the frost penetrates to considerable depths in this climate, and would be likely to reach the bases of these beams, but not so as to affect their stability. Were they lighter and shallower, however, its effects might be seriously detrimental to the stability of the track.

The holding-down bolts are spaced 3 feet 9 inches apart, making eight on the inside of each 30-foot rail, and there are two upon the outside of each rail, making ten 1-inch bolts by which each 30-foot rail is secured to its foundation. It is at once evident that this affords far greater security than is now obtained by about three times the number of spikes. The gauge rods are made from flat steel bars 6 feet 1 inch long for our Cincinnati gauge, with rail bases 6 inches wide and $\frac{3}{8}$ inch thick. "The ends are turned up to form claws, which engage the outer edge of the rail flange, and the central part is stamped into a semicircular trough shape, to stiffen it to resist compression. These bars are also punched to slip over the holding-down bolts. It will be seen at once that these gauge bars would offer vastly more resistance to the spreading of the rails than the present spikes in wooden ties. The rails would, in fact, be solidly held to perfect gauge. The

security of this, as compared with the rail braces, tie plates and spikes which are now used, will be apparent.”*

Regarding the subsoil drain, which is here shown as filled with coarse sand, the writer believes that to be the most effective material for the purpose, except in rare cases where the inflow of water would be quite considerable, when a tile should be bedded in the sand. It should be connected, by tile drains properly screened, with the sewers or other outlets for the water, at frequent intervals. In placing it in trenches, it should be well compacted, so as to aid in supporting the concrete beams. These trenches should not be filled with broken stone, especially in clay soils, as the clay will fill the interstices between the fragments of stone, and the drains will thus become entirely clogged. For the same reason gravel is inferior to sand. Where the subsoil is sand or gravel, the drains will not be required. The quantity of water to be carried by these drains is so small that it will seldom produce a running stream, but it is of the utmost importance that it be cared for, or its effects may be highly detrimental.

For suburban or interurban roads, a lighter form of construction may be used; but, even in such work, the form of track construction herein described would be found economical because of its permanency and the saving that would be effected in track repairs.

As heretofore stated, the writer does not claim much originality for the ideas of track construction advanced in this paper, but he does believe them to be in the nature of real betterments in the work, and therefore worthy of careful study, of elaboration, and, where found to be betterments over present practices, of adoption. The foundation should have the same ownership as the rail which it supports. As little reliance as possible should be placed upon street pavements for the stability of the tracks, and the least possible quantity of detriment to street pavements caused by the presence of the tracks. It is believed that the plan here presented will be conducive to those ends.

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THE DEVELOPMENT OF ROADS AND STREET PAVEMENTS.

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[Read before the Society, March 11, 1899.*]

ROADS which afford easy communication between countries, or different parts of the same country, promote social intercourse among the inhabitants thereof, and add wealth and power to the countries they traverse. These truths seem to have been recognized at an early age, and resulted in the paving of the streets of several of the ancient cities, it is said, as early as 2000 B.C., and from that time down to about the sixth century of this era. Babylon, Nineveh, Memphis, Thebes, Jerusalem, Carthage, Rome and others were paved with large flagstones, and it is said well-constructed highways joined the first four cities mentioned, notably one from Babylon to Memphis.

The first of the ancient roads of which we have exact descriptions were those of the Romans which joined the city of Rome with other cities of Italy, and extended to the remotest parts of the empire, notably into what is now Spain, Germany and France; to the Danube, and finally to Constantinople.

The oldest of all the Roman roads, the best preserved and probably the best known, is the Appian Way, often called the "Queen of Roads." It leads southward from the city of Rome, and was begun in the year 312 B.C.

It seems unlikely that all the Roman roads were constructed in the same manner, but I have been unable to find more than one general description, which is as follows: The first layer was composed of large, flat stones generally laid in mortar; upon this was placed a layer of concrete or rubble masonry of smaller stones, and finally for the top, or wearing surface, a paving of polygonal blocks of from three to six or eight square feet superficial area. These were hard stones jointed with great nicety and imbedded in concrete or mortar, the whole making a total thickness of about three feet; when upon a rock foundation the bottom course was omitted; on the contrary, when the foundation was very poor the thickness of the road was increased. Sometimes the top paving was omitted, and a covering of broken stone or burnt clay or pottery was used instead. The roadway varied from 8 to 20 feet in width, with a footwalk on either side (the roadway of the Appian Way is but 14 feet). They are described as running in a straight

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line, regardless of the nature of the country through which they pass. The latter feature would show very poor engineering, and, notwithstanding many statements by modern writers, I am inclined to think that due attention was paid in general to topographical features, and that the mode of construction was changed with the character of the country traversed and the nature of the material available for construction. Most writers have doubtless generalized too freely from facts obtained from an examination of the Appian Way, the line of which is practically straight for a distance of fifteen miles from Rome, and much further for aught I know; but in this distance the country is gently rolling, with no steep slopes. I am also inclined to doubt the statement that the paving was "jointed with great nicety." The poet Horace states that "the roads were less fatiguing to those who traveled slowly." My personal observations sustain this view. The paving of the streets of Pompeii, recently excavated after being covered and unused for eighteen centuries, is unusually rough, and there are many other evidences that the Roman roads, however durable and otherwise excellent, were lacking in smoothness.

With the decline of the Roman Empire and the general disintegration of society in Europe, about the close of the fifth century, the Roman roads fell out of repair and finally into ruin; and, although there was some little paving done in the cities of Paris, London, Florence and elsewhere as early as the thirteenth century, the common roads or highways between cities and throughout the country districts were in a frightful condition until near the close of the eighteenth century. So bad were the roads in England at this time that communication between districts only a few miles apart was practically suspended. Lord Macauley says that "it was no uncommon thing for the fruits of the earth to rot in one place when a score of miles away the people were suffering from a scarcity of the very food which was spoiling almost within their reach."

At this time each parish was obliged to build and maintain the roads within its confines, and oftentimes an impoverished agricultural community was expected to maintain a highway between rich and prosperous towns, a treatment of the subject eminently unwise and unjust.

During the latter part of the period between the decline of the Roman roads and the Renaissance, which began about the same time with Macadam and Telford in England and Tresaguet in France, probably the best roads then in use in the world were those of the Incas in Peru. These were the only roads, with the excep-

tion of those of the Aztecs in Mexico, found upon this continent. Even at the expense of making this paper too long, I cannot refrain from quoting here some passages from Prescott's description of the roads which the Spanish conquerors found there.

"Among them (great works) perhaps the most remarkable were the great roads, the broken remains of which are still in sufficient preservation to attest their former magnificence. There were many of these roads traversing different parts of the kingdom, but the most considerable were the two which extended from Quito to Cuzco, and again diverging from the capital continued in a southerly direction toward Chili.

"One of these roads passed over the Grand Plateau, and the other along the lowlands on the borders of the ocean. The former was much the more difficult achievement, from the character of the country. It was constructed over pathless sierras buried in snow; galleries were cut for leagues through the living rock; rivers were crossed by means of bridges that hung suspended in the air; precipices were scaled by stairways hewn out of the native bed; ravines of hideous depth were filled with solid masonry; in short, all the difficulties that beset a wild and mountainous region, and which might appall the most courageous engineer of modern times, were encountered and successfully overcome. The length of the road, of which scattered fragments only remain, is variously estimated at from 1500 to 2000 miles. Its breadth scarcely exceeded 20 feet. It was built of heavy flags of freestone, and, in some parts at least, was covered with a bituminous cement which time has made harder than the stone itself."

"The other great road of the Incas lay through the level country between the Andes and the ocean. It was constructed in a different manner, as demanded by the nature of the ground, which was for the most part low and much of it sandy. The causeway was raised on a high embankment of earth, and defended on either side by a parapet or wall of clay; and trees and odoriferous shrubs were planted along the margin, regaling the sense of the traveler with their perfumes and refreshing him by their shades, so grateful under the burning sky of the tropics."

These roads were used by footmen and four-footed animals only. No vehicles passed over them.

Just prior to the time of Telford and Macadam, England somewhat improved her highways by the establishment of a comprehensive system of post roads, but the construction was so imperfect that they were not much better than the old roads; and but little permanent improvement was observed until the advent of the two

men named, to whom the people of Great Britain are greatly indebted for the permanent and admirable system of roads everywhere found.

The methods of Telford employed in England and those of Tresaguet in France (the latter being the pioneer by a few years) are much alike, and are briefly described as follows: Upon a well-compacted and well-graded roadbed of natural soil a course of large stones is placed on edge, with the broad side down; these are rammed, and the interstices filled with smaller stones or chippings; upon this foundation is placed by hand and thoroughly compacted a layer of about 4 inches of smaller stones, and finally a covering of 2 inches of finely broken cubical stones, all pieces of which would pass through a ring $2\frac{1}{2}$ inches in diameter. The method of application of the different layers and the details of construction differ slightly, but the result in both cases was a good road; the thickness of which was from 12 to 14 inches, with a crown of about 4 inches. Telford made the crown with the bottom course of stone, while Tresaguet made it in the grading.

Macadam omitted the use of large stones for the foundation, claiming that they were not only useless but injurious; and placed the finely broken stone directly upon the natural soil foundation to a depth of 12 inches. He used stone broken to pass through a $1\frac{1}{2}$ -inch ring. None of these pioneer road builders used a binding material.

Modern macadam and telford roads are constructed in a manner similar to the above, except that the material is spread on in layers, with the addition of sufficient binder of stone clipping or fine gravel or sand to completely fill the void between the larger stones; and the several layers are thoroughly compacted by rolling. The best materials for such roads are basalt, syenite, trap, limestone and quartzose grits; most granites and sandstones are unsuitable, the mica causing them to grind up under traffic.

Such roads need constant care and intelligent supervision, and to save cost, both in construction and maintenance, should be only wide enough to accommodate the traffic. Ordinary country roads, unless near large towns, need not be macadamized wider than 14 feet, or sufficient only for two teams to pass easily. By maintaining a crown perfect drainage, the most important single element in road construction, will be obtained, provided the gradient of the road is sufficient to carry the water along after it reaches the ditches. The minimum grade adopted by the French engineers is eight-tenths of one per cent., and in level countries this is obtained artificially by introducing gradual undulations in the grading.

The gradient, up or down, upon which a horse can trot with ease is from $3\frac{1}{2}$ to 4 per cent. ; this, therefore, should be the maximum gradient, so that the lighter traffic can go quickly. If the ascent, as in a mountainous country, cannot be made with such a gradient it would doubtless be found economical to introduce stretches considerably steeper, but not too steep to be overcome by the heavier loaded vehicles ; under such an arrangement the lighter vehicles could make better time than if the gradient were continuous at a rate too steep to trot upon, and the heavily laden traffic by making a little additional effort could get over the steep places ; the adjustment of gradients, however, would depend largely upon the traffic expected.

Such roads as I have just described were built throughout France with great rapidity by Napoleon for military purposes, and all of Western Europe and Great Britain is now traversed by a system of well-built and well-kept roads, the best being those of France and Switzerland.

While there are some fairly good macadamized roads in this country, there are many more very poor ones, notwithstanding the vast sums annually expended upon their construction and repair.

Our roads have usually been constructed by local authorities untrained and unqualified for such undertakings. After the road is once built it receives no systematic supervision or care in its maintenance, an occasional load of gravel put on under the direction of the local supervisor being the extent of the attention bestowed. It is usually built too wide. From lack of care, the crown wears away in a few years, resulting in several parallel ruts, which are always partly filled either with dust or water, to be churned deeper and deeper by each passing vehicle until the road becomes concave and holds water even after the surrounding country has dried up. These defects of both construction and maintenance could doubtless be corrected by a systematic state supervision, and the application of scientific methods. It is my view that their supervision, both in construction and maintenance, should be by a state officer, and that a small tax should be levied and expended for maintenance under his direction, instead of a labor tax, as is now the universal custom.

The only instance of national road building undertaken by our Government was that of the national road which was started about the year 1840, and designed to run from tidewater to the Mississippi River. It was actually constructed from Cumberland, Md., to near the eastern boundary line of Indiana, with a branch, I believe, to Cincinnati. It was a creditable engineering work, and

would doubtless have been greatly extended but for the advent of the railroad, which afforded a better and quicker means of communication. It is about 30 feet wide and substantially constructed. The streams are spanned by wide bridges of latticed trusses on good masonry, almost all of which are still in use. It has long since been surrendered by the National Government to the States through which it passes, and although a toll road at the time I saw it the surface had been sadly neglected, and was concave and worn into several lines of ruts, which, as Horace said about the Roman road, "made traveling less fatiguing to those who went slowly."

STREET PAVEMENTS.

The first modern street pavements were mostly cobblestone, which was composed of boulders that had been worn smooth by the action of water and found either on the banks of streams or in gravel banks. The stones were usually from 4 to 8 inches long, and were imbedded in a foundation of about a foot of sand or fine gravel and rammed firmly to place; when finished the surface of the pavement was covered with from 2 to 3 inches of gravel and sand, which was worked into the interstices by the traffic. This kind of pavement was laid in Boston about the middle of the seventeenth century, and in Philadelphia fifty or sixty years later; subsequently much of it was laid in New York and Brooklyn, and still later in Cincinnati, St. Louis and other Western cities. It became the standard pavement for most American cities up to about 1850, and much of it is still in use.

This form of paving was succeeded by Belgium block, first laid in Brussels and later in Paris and the United States. It consists of rectangular blocks of stone from 6 to 10 inches wide, from 10 to 20 inches in length and about 9 inches deep, laid upon sand and gravel, with sand filling for the joints. After a little wear this makes an abominable pavement, very little, if any, improvement on the cobblestones. The large blocks wear in every direction toward the joints, leaving a series of boulders more or less convex, according to the amount of service received, and being exceedingly rough and noisy, and correspondingly severe on vehicles, horses and the nerves of the inhabitants. Neither pavement has any merit but durability, and is practically obsolete.

There seems to have been but little substantial improvement in American city pavements until about the year 1870, when asphalt and wood came into use both in Europe and America, and soon after, when a better grade of stone blocks were laid. About fifteen years ago the use of brick began mostly in the cities between

the Alleghenies and the Missouri River, and larger areas have since been laid with more or less satisfactory results.

Asphalt pavements are composed either of natural rock asphalt or refined asphaltum, mixed with residuum oil, sand and carbonate of lime. Most of the asphalt pavements of the United States consist of artificial asphaltic cements, made from asphalt brought from the island of Trinidad, or the mainland of South America near said island. The material from the several localities produces about the same result when properly manipulated. When freshly dug the crude pitch is saturated with water, cuts with a knife, like cheese, and is of a brown color; as it dries the color becomes a bluish black, and the bitumen becomes harder. The product, after refining, which is done with great care by a system of indirect heating, contains about 56 per cent. bitumen and 44 per cent. of earthy and vegetable matter. The refined product is put in barrels and transported to the place where it is to be used. It is then melted in kettles, and from 15 to 20 per cent., by weight, of petroleum residue added thereto. From 12 to 15 parts of this material, added to from 83 to 70 parts of sand, and 5 to 15 parts of pulverized carbonate of lime, form the wearing surface of the usual asphalt pavement.

The Barber Asphalt Company's first-class pavement—that designed for the heaviest traffic—consists of a foundation of 5 inches of hydraulic cement concrete, $1\frac{1}{2}$ inches of bituminous binder and 2 inches of wearing surface.

The second-class pavement—that designed for semi-business or residence streets—consists of 4 inches of hydraulic cement concrete, 1 inch of bituminous binder and $1\frac{1}{2}$ inches of wearing surface.

Asphaltum was used by the Egyptians and Arabians for cistern linings and similar purposes more than two thousand years B.C., and is used with success at the present time for reservoir linings; but not until about the year 1838 was it used for street paving, and it did not come into general use until about 1870.

It requires more careful manipulation and more skill in handling to produce a perfect pavement with the artificial, or prepared, product than with the natural bituminous limestones of Europe, or the bituminous sandstones found in California, Utah and elsewhere in the United States; this doubtless accounts for the many failures of such pavements soon after their introduction in this country. Experience, however, in the preparation of the material and the laying of the wearing surface has corrected most of the defects observed in the earlier pavements, and the results now obtained is nearly an ideal pavement. It is the easiest of all pavements to keep

clean, and produces neither dust nor mud. It offers the least resistance to traffic, and with reasonable care lasts from fifteen to twenty years; it is the least noisy of any excepting wood, and although very slippery under certain conditions of dampness, when either wet or dry, it is not objectionable for that reason if laid upon a grade of less than about 4 per cent. Notwithstanding popular opinions to the contrary, it is my belief that a first-class asphalt pavement similar to that just described will withstand successfully the heaviest city traffic, and that it is the most economical pavement now in use (when we consider the wear and tear on vehicles and horses) for the busiest streets of our large cities.

It costs in New York city about \$3 per square yard with fifteen years' guarantee; prices elsewhere have fallen to near \$2.25, and for second-grade pavement in many instances to about \$1.60. It may be said that the prevailing price now is about \$2. These prices usually carry with them a guarantee of from five to ten years, and a certain sum for repairs for a period thereafter. The granite block pavements now so generally used both here and in Europe are some little improvement upon the Belgium block which they succeeded, but on the whole they have little merit other than durability and that of affording a good footing for horses on grades too steep for other kinds of pavements. After becoming a little worn they are very slippery, either wet or dry; they are destructive alike to vehicles and horses, and under heavy traffic produce a noise distracting to those unused to it. It is claimed by many physicians that the continuous noise and clatter of the stone pavements is not only trying on the nerves of delicate people, but actually drives many persons to insanity.

Such pavements are expensive to clean, difficult to thoroughly clean, and are usually left badly cleaned, and therefore unsanitary, because of the accumulations of filth in the joints. Granite blocks are very durable, and seldom any part is wasted. Such pavements last from six to forty years, according to the location and traffic. On busy streets the blocks are taken up and turned over, or redressed, after a certain amount of wear; and after becoming entirely unfit for use they are crushed up to make concrete for other pavements, and thereby made to serve some useful purpose to the end.

The blocks are usually from $3\frac{1}{2}$ to 5 inches wide, from 8 to 14 inches long and about 7 inches deep, and should be dressed rectangular and free from projections which make a joint between the blocks greater than $\frac{3}{4}$ of an inch. The smaller the block the better the pavement, for when they are worn in every direction, from the middle toward the joint, they become so many boulders,

and the smaller the boulder the smoother the surface of the pavement.

Most stone pavement is laid on a foundation of sand, above old macadam roadways or a roadway compacted by ramming or rolling. The blocks are simply imbedded in the sand and rammed to a firm and even bed, and the joints filled with fine gravel and hot paving cement. The latter is usually a product of coal tar, with sometimes an addition of asphaltum. The paving cement is intended to thoroughly fill the joints and make the pavement impervious to water. To do this requires from 2 to 4 gallons of paving cement for each square yard. This is often improperly done, and I have doubted its efficiency and wondered whether the result justified the additional cost, which is from 20 to 40 cents per square yard.

Such pavements without a concrete foundation are usually so villainously bad that nothing could either make them worse or improve them. Recently it has become more general to place them upon a concrete foundation. This is a great improvement, and justifies care and expense in their laying.

The cost of granite block pavement varies from \$2 to \$4.50 per square yard, according to the locality, the foundation and the care used in cutting and laying the blocks. Such pavement is, in my humble opinion, fast becoming obsolete and fit only for wharves, the steeper grades and wholesale districts where the streets are used solely for heavy trucking. It is entirely out of place in any of the streets of Chicago, or on Broadway or Fourth or Fifth avenue in New York, or on any busy retail or residence street. Such streets should be paved with asphalt or wood.

Brick pavement is yet in the experimental stage, and this paper is already so long that I shall treat it but briefly.

Its success depends upon the tenacity of the material, its uniformity and the character of the foundation. The foundation, like that for all pavements, should be impervious and unyielding. Often a layer of brick placed upon their sides is used as a foundation for the top course, which is always laid upon the edge with close joints; the usual custom is to fill the joints with a paving cement; sometimes this is omitted, but with what practical results I am unable to say. Much of this pavement has been laid in the Middle West at a small cost, and for ordinary traffic it has given good satisfaction. It has been laid for as little as 70 cents per square yard, and ranges from that up to \$2.

I desire to treat wood pavements more at length, because I believe the importance of wood as a paving material is not recog-

nized in this country. Indeed, there seems to be a popular prejudice against it. On the contrary, it is greatly in favor in European cities, where its use is steadily on the increase.

The use of wood as a paving material began in this country about the year 1870, with the Nicholson pavements, which as a rule proved a failure. This was followed by the introduction of the round cedar blocks, which were placed upon a foundation of broken stone, sand or gravel, or upon 2-inch plank.

This class of pavement was extensively used in the Western States, and, being very cheap, many new towns and cities were able to use it at a time when a more expensive pavement was not available because of a lack of funds.

The cost ranges from 70 cents to \$1 per square yard. If placed upon a foundation of concrete, which is the latest practice, it is increased to from \$1.50 to \$2.25 per square yard. A filling of coarse gravel and paving cement for the joints is used in the better grade of pavements, but the additional expense of 15 or 20 cents per yard for the paving cement is hardly justified in the cheaper grades, and is often omitted.

Its life is from seven to eleven years. Although smooth when first laid, after a few years' wear it becomes somewhat rough, because of the more rapid wearing of the sap than the heart of the wood, leaving it a series of round humps.

The Helena wooden pavement, which many members of this Society has seen, is composed of fir blocks 4 inches wide, from 8 to 12 inches long and 6 inches deep, laid upon a broken stone foundation on Main street and upon plank on Grand street. This pavement has been down eight years, and has given satisfaction to the residents of Helena. The joints were filled with a paving cement and fine gravel, and are from $\frac{3}{4}$ to 1 inch in width; the blocks are tightly wedged together, and cannot be removed without considerable labor. The pavement seems to have been well laid, but shows one very serious defect,—that of having the joints too wide. As a result they have worn rounding on top, and it is now rougher than it should be; and rougher than it would have been had the joints been but $\frac{1}{4}$ of an inch in width. A block 3 inches wide would have made a better pavement.

I took up this pavement in a number of places about two years ago for the purpose of inspection, and found a decay at the base of the blocks extending up 2 or 3 inches in all blocks taken from Main street. Those laid upon the plank foundation on Grand street were perfectly sound, although laid at the same time. I think this pavement cost \$2.50 per yard.

Such pavements as I have described are noiseless, afford excellent footing for horses and are easily and quickly laid. They have usually been selected, however, because they were cheap in first cost.

European wooden pavements are very different from those usually seen in America, and would not be recognized as wood without close inspection. This is the paving material used on the busiest and most important streets of London, and the busy and fashionable avenues and boulevards of Paris. It is also used in Berlin, but, as that is essentially an asphalt paved city, the use there is less extensive.

The construction there is briefly described as follows: Upon a foundation of 6 inches of concrete a bed of cement mortar less than half an inch in thickness is spread and made very smooth, and parallel with the crown of the finished street. After this has become hard the wooden blocks are placed directly upon it, with joints of about $\frac{1}{4}$ of an inch. The joints are maintained during the laying by brads driven into the side of the block to a shoulder. The joints are then run full of hydraulic cement grout, or sometimes paving cement for about 2 inches and then the grout. The blocks are sometimes treated chemically to preserve them, but usually they are merely dipped in creosote oil and allowed to dry. Sometimes wood in its natural state is used. The timber is sometimes seasoned, but often only partially so.

The Improved Wood Paving Company, of London, uses partially seasoned timber, and simply dip the blocks.

The blocks are usually of pine, 6 to 10 inches long, 3 inches wide and 6 inches deep. Some hard wood has been used with more or less success. It is more expensive, however, and has proved more slippery than the softer wood. This standard pavement costs in London about \$1.80 per square yard, exclusive of foundation. Fine gravel or shingle is scattered upon the finished pavement, and at intervals during its use; this is driven into the wood by the traffic, and is said to make it less slippery. Its life upon the busiest streets is about eight years; on the less important streets from ten to sixteen years.

The following extract from the *Engineering News* of July 14, 1888, may prove interesting in this connection: "Wood pavements have met with greater success in Europe than in America because they are laid upon a foundation of concrete, and receive more attention in the way of maintenance than is given them here. American yellow pine, owing to its hardness and resinous quality, has been the favorite wood in Berlin and Hamburg. A report from Berlin

states that the Frederick Bridge was paved in March, 1879, with yellow pine and is still in good condition, while the approaches, paved with granite block, have since required twice repaving. The Opera Platz in front of the Emperor's palace was paved in 1882 partly with yellow pine and cypress at the point where the traffic was greatest; at the other points stone blocks were used, and were laid at the same time. To-day the area having the wood pavement is the one which is the best preserved."

This pavement affords a good foothold for horses, offers very little resistance to traffic, is the least noisy of all pavements, will stand the heaviest traffic and altogether has so many points of merit as to place it in the very front rank as a paving material. I should place it along with, if not superior to, asphalt for the finest and busiest streets of our large cities, but I do not recommend it as a cheap pavement designed for secondary or resident streets.

It has usually been so considered in this country, and to that, more than any other reason, I attribute the unfavorable opinion generally held concerning it. It was made of cheap, untreated material, carelessly laid upon an inadequate foundation; necessary repairs were entirely neglected, and has by no means had a fair chance, while in Europe it is composed of the best grade of material, generally treated to prevent its absorbing urine and other deleterious matter; placed upon an impervious and unyielding foundation; that requisite for any good pavement, and laid with great care by skilled workmen, and always kept in excellent repair.

It is in no sense a cheap pavement, and should not be so considered.

If there is luxury in street paving, as in almost everything else at this age, I see no reason why wood should not, along with asphalt, come into general use. In most things our comfort, ease and pleasure are important considerations. In the ordinary walks of life a man doesn't dress himself in duck or corduroys, or in any way select his apparel, strictly because of its durability or economy. He selects that which is comfortable, pleasing to the eye and otherwise suitable to his occupation, condition in life and general environments; while, on the other hand, in the majority of instances durability and first cost are the only factors considered in the selection of a paving material. Why the people residing or doing business on our wealthiest streets should submit to a rough and noisy stone pavement, when a first-class wood or asphalt pavement is entirely within their means, has always been a surprise to me; and I cannot but attribute it to lack of knowledge of the results obtained elsewhere, with very little if any more cost.

DISCUSSION.

In the discussion which followed the members generally agreed with Mr. Blackford that properly constructed wooden blocks and asphalt pavings were the best under the most trying conditions.

MR. C. W. SWEARINGEN, City Engineer of Great Falls, stated that the paving in Great Falls is cedar blocks on 6-inch concrete foundation, 1-inch sand cushion, with filler of gravel and pitch, and 5-inch granite curb. The cost was as follows: Paving \$2.50 per square yard; complete curbing \$1.25 per linear foot. The paving has been in use three and a half years on the principal street, and so far has proved very satisfactory.

**ADDRESS BY JAMES M. PAGE, RETIRING PRESIDENT,
BEFORE MONTANA SOCIETY OF ENGINEERS, AT
ITS 12th ANNUAL MEETING, IN HELENA,
MONTANA, ON JANUARY 14, 1899.***

TO THE MEMBERS OF THE MONTANA SOCIETY OF ENGINEERS:

The Montana Society of Engineers was organized July 5, 1887, with forty-eight charter members. Out of these twenty-one are now active, four honorary and seven associate members of the Society; thirteen of the charter members have withdrawn and we have lost four members by death, two of whom—Benj. H. Greene and Walter W. DeLacy—were occupying the office of President of the Society at the time of their decease.

We have had an addition of twenty-two members during the past year, and we now have honorary members four, active members one hundred and twelve, associate members eighteen, the total being one hundred and thirty-four.

I like the plan adopted by my predecessor in his annual address at Butte, a year ago, in giving a review of the year's engineering progress in our own State, and I am sorry I can only partially follow his example.

NORTHERN PACIFIC RAILROAD.

Charles S. Bihler, engineer of the Western Division of the Northern Pacific Railroad, located at Tacoma, has kindly furnished me with the following very complete information regarding improvements made by the Northern Pacific Railroad in Montana during the past year.

East of Billings.—Revision of grades between Glendive and Montana State line, from 1.25 to 1 per cent. virtual grade.

Revision of grades between Glendive and Billings to an 0.4 per cent. westbound and an 0.25 per cent. eastbound; former gradients 0.5 per cent. each way.

Improvements of line around Big Horn, Myers, and Huntley Bluffs, throwing out 50 per cent. of curvature and getting away from bluffs, in order to insure safety of trains.

New construction, branch from Rockvale to Bridger, 20 miles.

134 pile bridges filled or renewed with steel; 80 miles of track newly ballasted; 20 miles main line 56-pound steel rail replaced by 72-pound steel; new and improved coaling stations at Miles City

*Manuscript received February 17, 1899.—Secretary, Ass'n of Eng. Socs.

and Forsythe; Big Horn Tunnel lined throughout with concrete walls and concrete arch.

West of Billings.—Revision of grades between West End and Bozeman from 2.1 to 1.9 per cent. virtual.

Revision of grade between Bozeman and Logan from 1.0 to 0.8 virtual.

Revision of grades between Garrison and Avon from 1.0 to 0.7 per cent. virtual.

95 miles of track ballasted.

45 miles of 56-pound steel rail replaced by 72-pound steel.

Roundhouse addition, 6-stall, at Livingston.

Car shop addition at Livingston.

Roundhouse addition, 6-stall; boiler house and improved coaling station at Missoula.

Improved coaling stations at Garrison and Jocko.

22-stall roundhouse, boiler house, sand house, oil house and cinder pit under construction at Butte.

Big Boulder bridge at Big Timber replaced with steel structure.

3974 lineal feet bridging filled.

New construction—Branch from Renovo (Parrot) to Twin Bridges, 22.4 miles.

I am indebted to Mr. Eugene Carroll, chief engineer and superintendent of the Butte Water Works, for the following:

“The Butte City Water Company, during the year, 1898, has built, above its main reservoir, an additional settling basin of about 70,000,000 gallons capacity, formed by a crib dam 42 feet high by 300 feet long on the crest. This basin was built for the purpose of settling the spring freshets before the water is allowed to enter the main reservoir, and also to give us additional storage during the low water season.

“In the city we have extended our mains about two miles to cover new districts built and improved during the year.”

The irrigation scheme in the Jefferson Valley, mentioned in Mr. Goodale's address of last year, was completed this year and used during the month of August. The completed ditch is about 13 miles long, and has a capacity of about 1200 miner's inches. During the present year we kept the ditch only about one-half full, so as to get everything settled and in good shape before testing its full capacity. As far as can be seen at this time, it will be a success and will be used by five different ranches in the valley.

This is all the work which has been done under my supervision during the year 1898, with the exception of the completion

of the cleaning of the bottom of the main reservoir, from which we removed, during 1898, about 20,000 cubic yards, with a view of avoiding the spoiled water with which we have been annually troubled in Butte. The surface earth was removed from the bottom of the reservoir to the depth of at least four feet, so as to remove all vegetable organisms.

MADISON CANON DAM.

Mr. O. B. Suhr, the engineer in charge, whose headquarters are now at Norris, Mont., has kindly furnished me a few notes on this new enterprise, although he says that he can give no definite information as to details, as the plans are yet incomplete. The dam site is located in the Lower Madison Cañon, three miles below Case's ranch, and about eight miles southeast of Norris.

"In a distance of nine miles there is a fall of 276 feet, out of which there is obtained an effective head of 200 feet by means of dam and flume.

"The work is now being prosecuted on a small plant of 501 horse power output, which is designed to furnish the local power market and to supply power for the larger construction, which will have an output of 10,000 horse power to be transmitted to Butte.

"Up to this time the work has been almost entirely preliminary. A wagon road is just completed down the cañon to the dam site, for the small plant; a bridge is in process of construction across the river, and some work has been done on the dam."

From other sources I learn that, to build this dam, a tunnel is run in the overhanging cliff and filled with powder, and, when they are ready for the dam, the fuse will be lighted.

Mr. A. E. Cumming, Engineer and Superintendent of Construction of the Fort Belknap Irrigation System, says that the enterprise is only fairly started.

The proposition is for the Government to provide an irrigation system for the Indians on the Fort Belknap Indian Reservation.

The work is done by the Government for the Indians and paid out of moneys due them for lands sold to the Government under treaties of 1890 and 1896. So far, the Indians have done all the work and are reported by Mr. Cumming as being fairly good workers.

After a careful examination of the water supply available for irrigating purposes on the Reservation, Mr. Cumming reports to the Department that Milk River may be utilized to irrigate the

fine bottom lands lying east of the agency on the Reservation. This and Big Warm Spring Creek are the only streams on the Reservation that can be utilized for a practical system of irrigation.

The water is to be taken from the river by a dam which is to be a "crib 7 to 9 feet high, filled with rock, the crest being about one foot above the bottom of the canal. It will be 8 feet wide on top and 250 feet long, with a triangular section extending up stream, with the top sloping to the bottom at an angle of about 36° . The entire crib is to be covered with 3-inch plank with sheet piling driven well down in the bed of the stream along the entire bottom of the dam to prevent leaking underneath. The water is to be raised 4 feet above the top of the dam by flashboards, which will be removed during high-water season. This dam will make an available storage supply of from 50,000,000 to 60,000,000 cubic feet, as a lake will be formed 10 to 12 miles long, an average of 200 feet wide and 5 feet deep, in addition to the flowing supply of the river. This will furnish enough water to cover 2000 acres two-thirds of a foot deep. The estimated cost of the dam and head works is \$11,535. The water supply from Milk River at its flood stage has a flow of 5500 to 6000 cubic feet per second. There are no official data available of the amount of water flowing in the river during each of five months, beginning with May to September."

It is proposed to utilize the water from Big Warm Spring Creek by building a reservoir which will cover 150 acres, in which the water will be 50 feet deep at the deepest part when full. This reservoir supply, it is expected, will furnish water to irrigate 3000 acres.

The work thus far has been done at a cost of less than 10 cents per cubic yard for excavation.

THE MONTANA POWER COMPANY'S DAM.

The dam across the Big Hole River, near the mouth of Divide Creek, you will remember, was a source of considerable discussion at our last annual meeting. Many of you visited this dam at that time, and hence you are familiar with the plan upon which it is built, and with its topographical surroundings.

It is a timber crib structure, 60 feet in height at the spillway, with a base of 100 feet in width and 500 feet in length.

At the discussion referred to, it appeared to be the opinion of all who had visited it, as well as of the engineer in charge, Mr. M. S. Parker, that the dam, which was nearing completion, was

built on the correct plan, considering the character of the stream, and with all the necessary precautions as to its strength and its durability to resist the pressures that may be brought against it. Mr. Fanning, the consulting engineer (who, I understand, planned the structure), has a world-wide reputation as a hydraulic engineer, and it was believed that he would not be associated with a project which would endanger life and property below it; that the company would not spend half a million dollars in an unsafe structure, and that everything had been done and was being done to insure perfect construction, etc.

Mr. Parker has a very able article in the *Engineering Record* of August 6, last, describing a "partial failure of this dam," from which I quote briefly:

"On April 18, the dam not being fully completed, the maximum flow of the stream for this year was reached, coming fully six weeks earlier than the usual time of high water of the stream. In three days the volume of the water increased from the normal flow of 350 cubic feet per second to ten times that amount, and, notwithstanding that the two sets of waste gates provided were open, one located 50 feet below the crest, with a discharge area of 54 square feet, the other set 20 feet above, with an area of 40 square feet, the water rose to a height of 4 feet over the crest."

This unexpected pressure proved too much for the structure and caused a partial failure, the extent of which will undoubtedly be given you in Mr. Parker's paper on this subject to-day.

I refer to this dam chiefly because the question as to what is the best and safest plan for building dams in our mountain streams is of the most vital importance to the engineering profession in this state. These streams, owing to the rapid melting of snow along the many tributaries early each season, are subject to change in a few hours' time from a gentle flowing stream of a few thousand inches of water to a raging torrent.

RAILROAD CONSTRUCTION.

According to the latest reports at hand, 3018 miles of new railroad have been constructed in the United States during the past year. This is 1138 miles more than in the year 1897, and more than any year since 1892. There are five States in which no new track was laid, three States had only two miles each, and thirteen States over 100 miles each; Nebraska added less than one mile, and Minnesota 250, of which 146 miles were constructed by the Great Northern Railroad.

The retiring Presidents of the Society, for the past two years,

have pointed out that men of engineering skill and experience should be appointed by the Executive to positions where such qualifications would be of decided advantage to the State. It is a question yet to be answered why it is that the State should not have the benefit of the services of men fitted by education, training and experience to fill positions especially connected with the Land Department, where such training and experience are of vital importance in handling and protecting our various land grants.

In conclusion, I congratulate you on the very gratifying increase of membership in the Society during the past year, and upon the prosperous and generally healthy condition of our Society; also on the broad ground of American citizenship.

As a nation we have made history faster during the past year than during any like period since the landing of the "Mayflower." Spain forced upon us the gage of battle, which we accepted with reluctance, but not with fear, knowing full well "that chains are worse than bayonets, even though the chains were on the limbs of others, and the bayonets directed at ourselves."

Spain had the satisfaction of blowing up the "Maine" and killing 266 Americans, and it has cost her 21 warships, two armies and over 160,000 square miles of her territory. A year ago she governed over 10,000,000 people outside of her own limits. Now she governs less than 200,000.

But, after all our grand achievements, both on land and sea, and acquisitions of territory, it is a serious question in the minds of some of our best statesmen whether it would not have been better for us as a nation if Dewey had sailed away after destroying the Spanish fleet in the Manila harbor. A few months since we were not acquainted with ourselves as a nation, but the prestige of our country is greatly increased throughout the world, and our flag has taken on new splendors. I firmly believe that the United States is capable of solving any question and of handling anything that it undertakes.

PARTIAL FAILURE OF THE TIMBER CRIB DAM OF THE MONTANA POWER COMPANY NEAR BUTTE, MONTANA.

BY M. S. PARKER, MEMBER OF THE MONTANA SOCIETY OF ENGINEERS.

[Read at the 12th annual meeting of the Society on January 14, 1899.*]

THE main object of this paper is to call to the attention of engineers some of the elements of failure to be guarded against in the construction of high timber crib dams, and to give the writer's views as to some precautions necessary to be taken to avoid disaster.†

The timber crib dam has for many years been popular in the United States, where economy in first cost has been considered necessary, and it will continue to be popular there. This form of dam, however, is rarely built to a height exceeding 30 feet, although there are no valid reasons why these structures should not be carried up to any desired height when the necessary precautions are taken.

There are instances where the construction of solid masonry dams is beyond the range of possibility, from the standpoint of financial success. The instance herein mentioned is one in point. The site of the dam is in a canyon, well calculated to sustain a timber crib dam. The foundation for the dam is composed of large boulders, fine and coarse gravel, embedded in stiff yellow clay. Above this underlying stratum is loose gravel, sand and boulders. The site of the dam lies between two parallel ledges of rock, one of granite, the other of quartzite. These ledges run at an angle of about 45° with the course of the stream. The bottom of the gorge, through these ledges, is of unknown depth; and the north end of the dam rests in a V-shaped formation in the granite ledge that stands at an angle of about 10° from the perpendicular, forming an excellent anchorage. The south side also has excellent anchorage in the ragged sides of the quartzite ledge. The depth to the solid bed rock, between these parallel ledges at the point of contact, is undetermined, but, from indications, it must be very great. No soundings were made, as it would have involved large expense to determine the depth to bed rock, and the

*Manuscript received March 23, 1899.—Secretary, Ass'n of Eng. Socs.

†NOTE.—This dam was referred to in C. W. Goodale's Presidential address. See address and views of dam in Vol. XX (1898), No. 5, p. 313; also, Canyon Ferry Dam, referred to by Mr. Parker in same volume and number.

character of the foundation as obtained was considered suitable for the construction of the type of dam to be built.

To obtain a bed-rock foundation for a masonry dam placed the enterprise beyond the reach of financial success. The general plan of the plant of the Montana Power Company is familiar to some of the members of the Montana Society of Engineers, who visited the work during the last annual meeting of the Society, and the President in his annual address gave a general description of the work contemplated.

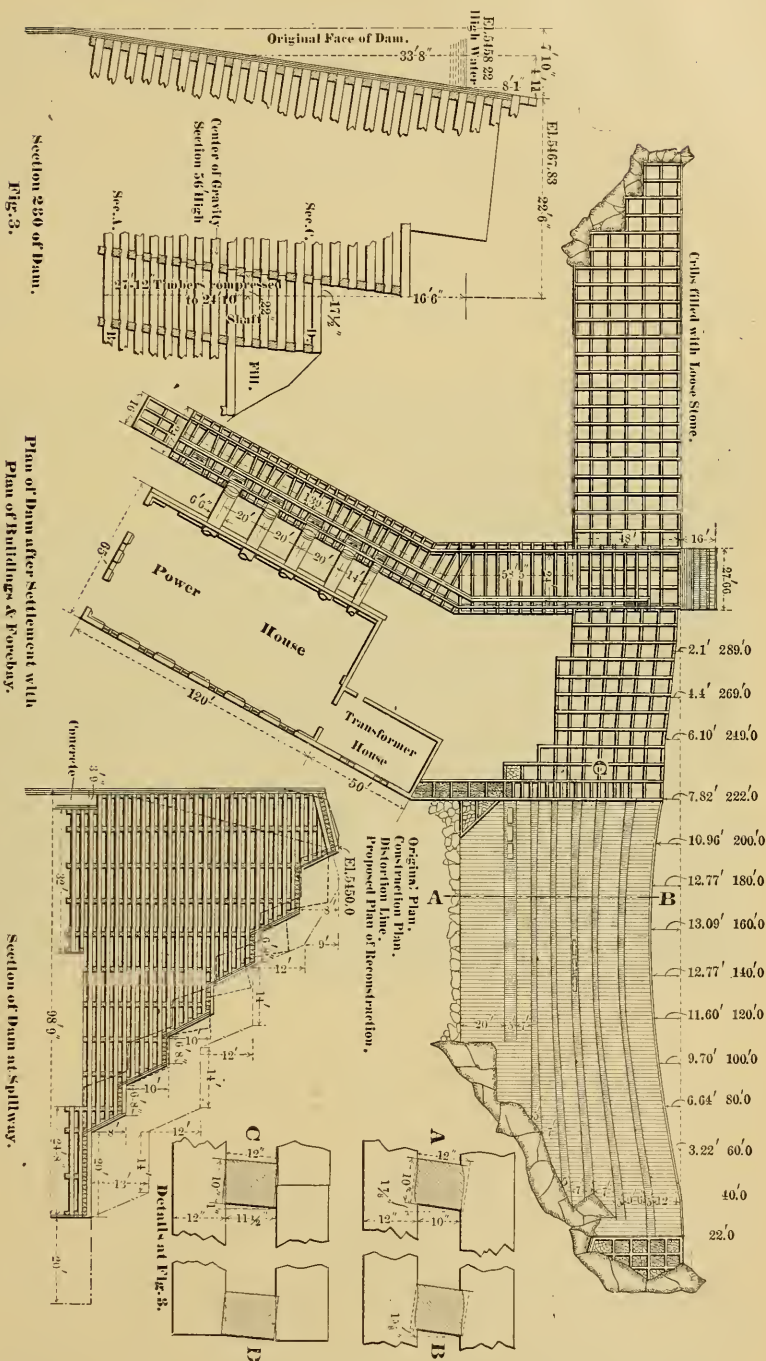
Before entering into the details of the causes of the partial failure of the dam, it may be well to give a general description of the power of the plant of the company, its object, and the conditions governing its inception.

The plant is located on the Big Hole River about three miles from Divide Station on the Oregon Short Line Railway, the object being to generate power and transmit it by electricity to Butte, about twenty miles distant.

The development involves the construction of a dam 60 feet high, to obtain head for the operation of turbine wheels. The water supply thus obtained for the reservoir is to be supplemented by water from two storage reservoirs located about 20 miles above the main reservoir at the plant, on the north and south forks of Wise River, a tributary of the Big Hole River. The reservoir on the north fork has an estimated capacity of one billion cubic feet, while the south fork reservoir is estimated to contain about half this amount.

The combined capacity of the reservoirs would be about 1,500,000,000 cubic feet. This amount of water, utilized for power purposes under the 60-foot head obtainable at the power station, is equivalent to 325 gross horse power per day for one year. Having this amount of water in reserve, it will be readily understood that the normal stage of water in the power reservoir can be maintained, so that the established minimum flow shall not fall below the quantity estimated for power purposes. The average minimum flow of the Big Hole River at the power station was found by the writer, from measurements taken daily from August, 1897, to April, 1898, to be about 350 cubic feet per second.

During this period, while anchor ice was obstructing the flow, the minimum flow would sometimes run as low as 250 cubic feet per second. From intermittent measurements, taken during several previous years, the minimum flow was assumed to be greater than that found by the writer during the time of his measurements. The company had based its investment upon the pre-



Section 230 of Dam.
Fig. 3.

Plan of Dam after Settlement with
Plan of Buildings & Forebay.
Fig. 2.

Section of Dam at Spillway.
Fig. 1.

DIAGRAMS SHOWING DISTORTION OF THE TIMBER DAM OF THE MONTANA POWER COMPANY.

vious measurements, and had assumed an average minimum flow of not less than 400 cubic feet per second. This amount of water, utilized for power under a 60-foot head, is equivalent to 2720 horse power.

Assuming a 75 per cent. working efficiency for the turbines and a further loss of 10 per cent. in the transmission of electricity to Butte, the works would make a net delivery of 1836 horse power in Butte.

The investment was based upon the commercial value of this amount of power. To maintain this estimate of 400 cubic feet per second was the object of the storage reservoir system mentioned, which had not been contemplated in the original plan of power development. Upon the commercial value of this power delivered in Butte it was estimated that the project would support a capital investment of \$500,000. After considering several plans for development, one for the construction of a solid masonry dam 60 feet high, another for building about two miles of large steel conduit in connection with a low dam for acquiring necessary head and volume of water, the form of dam hereinafter described was adopted. The plans formerly proposed placed the cost of development beyond the capital obtainable for the purpose.

These facts are mentioned merely to explain why a rock-filled timber crib dam was built, instead of a solid masonry dam.

A section of the dam at the spillway is shown in Fig. 1. This is constructed of 10 x 12-inch pine and fir timber, laid in cribs with 8 feet between centers. The height of timber is 12 inches and the crib work is filled with broken granite. The fine material is obtained by stripping and quarrying the granite. Openings between the timbers were packed by hand with broken granite of irregular surfaces, while the interior of the cribs was filled in loosely with the above-named material, dumped from cars. (Fig. 4 shows the high section of the dam beyond the spillway section.) The dam has a length of 500 feet with height of 60 feet from low-water mark to crest of spillway. The width of spillway is 200 feet. The rest of the dam is 10 feet higher than the spillway, and the spillway section consists of a series of steps 10 feet high, the tread or apron of each step being 7 feet wide and consisting of two layers of timber each 10 inches thick.

The high section of the dam, Fig. 4, is carried up in 10-foot steps with vertical faces, which are filled to a uniform slope from the original ground surface.

Fig. 5 is a view of the spillway section under construction.

The face of the dam consists of three layers of plank securely spiked to the crib work. The first layer is of 2-inch plank. Over this is a 3-inch plank, breaking joints with the first and secured to the crib timbers with 10-inch boat spikes, two spikes to every face timber. Over this is a third layer of 2-inch plank, also breaking joints. All plank used was surfaced on one side and placed vertical on the face of the dam.

The crest of the spillway, like the aprons above described, is composed of two layers of 10-inch lumber, with the seams calked with oakum. All the timbers, of crib work and aprons, were

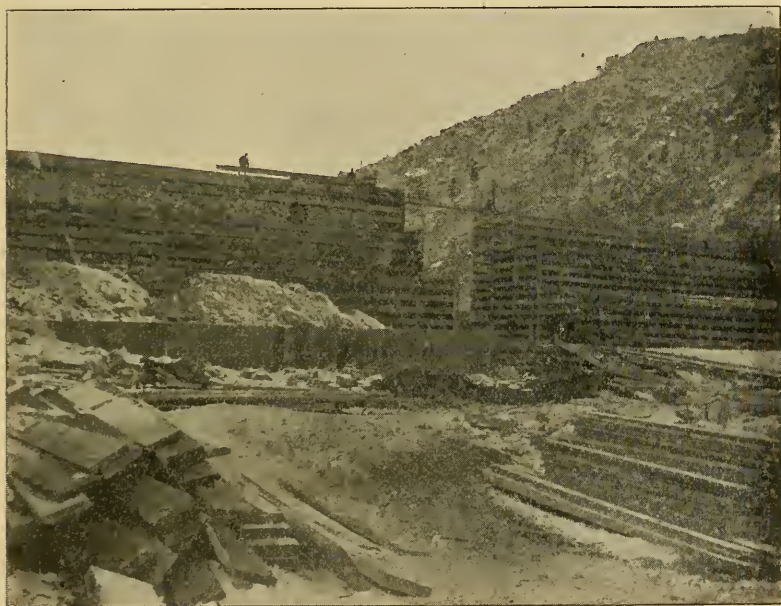


FIG. 4. VIEW FROM BELOW DAM DURING CONSTRUCTION OF HIGH SECTION.

securely bolted with drift bolts $\frac{3}{4}$ -inch square, 20 and 28 inches long. Two 28-inch and three 20-inch bolts were used in each 16 feet of timber.

As before mentioned, the bottom of the foundation of the dam is a bed of stiff, yellow clay, with boulders and gravel cemented together. The depth of the foundation, below the original surface of the ground, varies from 12 to 25 feet on the face of the dam. This depth is filled with a strong, concrete core composed of one part Utah Portland cement, two parts clean sharp sand and five parts broken stone. This core is 3 feet 9 inches thick and extends from the foundation to about 6 feet above the original surface of

the ground. It follows the face planking down and is confined at the back by layers of 2-inch plank spiked to the crib work, as shown in Fig. 1. Concrete is also used in front of the face planking for about 10 feet above the foundation. The excavation, made in reaching foundation, is back-filled with it across the river bottom, extending from the north end of the dam for about 300 feet. The remainder of the excavation for foundation, outside of the planking, is filled with a semi-clay puddle rammed in layers to the height of the original surface of the ground. Above this clay puddle and concrete filling, on the up-stream face of the dam, is an embankment of silt, with a slope of 3 feet horizontal to 1 foot in height. This embankment is about 15 feet high above the concrete filling on the face, and about 6 feet high above the clay puddle. The face planking is relied upon to prevent leakage, the granite filling for weight only. Water is taken from the dam, through gates, into a large wooden flume or fore bay, 28 feet in depth and 15 feet in width. The power house is a granite and concrete structure, with a steel truss roof. The building is 120 by 65 feet in plan, with an annex 50 by 30 feet for transformer house. The power house is divided into two bays by an interior row of columns, which support two traveling cranes, each of $7\frac{1}{2}$ tons capacity. It was the intention to supplement the water power with a steam plant. Hence the power house was made much wider than would have been necessary for water wheels and generators alone.

From the fore bay, five steel penstocks lead to five 66-inch turbines of special design. Each turbine is directly connected to a generator, and on the generator shaft is a coupling for engine connection.

The turbines are made by the James Leffel Company, of Springfield, Ohio. When running at 180 revolutions per minute, with a head of 60 feet, they are guaranteed to generate 1200 H. P. Lombard governors are used for regulation, and are guaranteed to regulate the power within 5 per cent. under any conditions. The water that will operate these governors is taken from the fore bay and filtered before it passes into the operating cylinders. The generators, of which four will be installed, are of the 3-phase type and are furnished by the General Electric Company. The generators are of 1000 H. P. capacity each, and of the revolving field type. Current is generated at 800 volts, but is raised to 15,000 volts by the transformers, of which there are 12, of 250 kilowatts capacity. The excitors, two in number, of 100 kilowatts are sufficient to excite five generators. Each exciter is

directly connected to a turbine running at 600 revolutions per minute.

The pole line measures 20.6 miles in length. Poles 30 to 60 feet in height are used, in order to maintain, as nearly as possible, uniformity of grade. Power is to be transmitted by six No. 1 B. & S. copper wires, with an estimated loss of 9 per cent. at maximum load. The poles are set about 50 per mile. Each pole supports three cross-arms, the upper ones $10\frac{1}{2}$ feet and the lower ones 3 feet long. The top of the pole and the ends of the upper cross-arms support glass insulators, to which barbed wire is attached

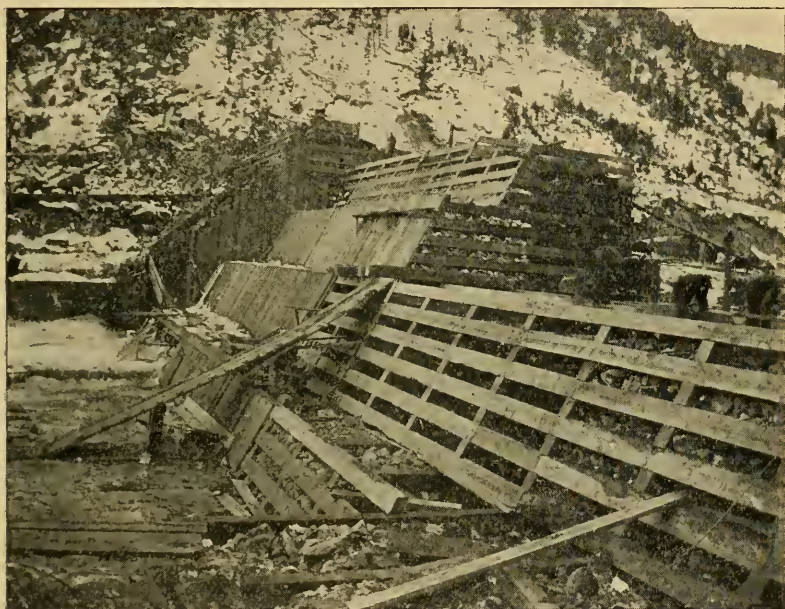


FIG. 5. VIEW FROM BELOW DAM DURING CONSTRUCTION.

as a lightning arrester. The barbed wire is grounded every 500 feet. The middle arm is for power wires, which are supported by porcelain insulators. The lower arm is for telephone wires. The foregoing is a general description of the plant, as designed, without going into details.

Work on the plant was suspended June 1, and the writer severed his connection with the company. He is informed that several changes have been made in the plan as herein outlined. A penstock, 11 feet in diameter, has been substituted for the large wooden flume, as intended in the original plan. The change was made under direction of the president of the company.

A tunnel is to be cut through the ledge on the north side, to be used for a waste way to drain down the pond. The waste way will be regulated by a system of gates, arranged to control the flow. The transformer building is also omitted. Except for these changes, the writer understands that the plant is to be finished as before outlined.

The promoters of the Montana Power Company had the project of the development of this power under consideration for several years, with Mr. J. T. Fanning, a well-known hydraulic engineer, as consulting engineer. Plans were finally matured, and the contract for construction was awarded. The writer was then engaged as engineer in charge of construction, and the active work of construction begun September 1, 1897. The company desired the work pushed to completion at the earliest possible moment, and stipulated in the contract a period of ninety days for its completion. This clause, however, was subsequently stricken out, and a more reasonable one substituted, requiring all possible haste consistent with the employment of sufficient labor and means. Work was carried on throughout the winter months without cessation, few days being too severe for men to work. Under such conditions, work was not only very expensive to the contractors, but in some respects less satisfactory than it would have been under more favorable conditions of temperature.

The excavation under water for foundations was accomplished under great difficulties. Constant annoyance arose from the freezing of steam and water pipes, and from the ever-present ice that formed on everything coming in contact with water. It was only by persistent work and at great loss to the contractors that the dam was finally completed.

About the 10th of April, 1898, the water in the river gave indications of an early rise. Work on the up-stream face of the dam was pushed as rapidly as possible, as well as work absolutely necessary to be done in advance of high water. It was the intention to close the waste discharge gates, of which there were two sets, prior to the period of high water, in order to fill the reservoir slowly, and to allow all settlement of the dam to occur gradually. One set of these waste gates was located at an elevation of 50 feet below the crest of the spillway, the other set 20 feet below. The lower set had an open water area of 60 square feet, while the upper set had a clear area of about 50 square feet.

The openings through the dam, for water to discharge from these waste gates, were sheeted over with two layers of 2-inch plank. The sides and roof of the sluices were of solid 10 x 12-inch

timber, and each waste sluice was divided into three compartments. The plan of gradually filling the reservoir was upset by the early flood that reached its maximum flow on April 18. The water rose so rapidly that in forty-eight hours it attained a depth of several feet above the spillway crest, although the waste gates were all wide open. The estimated flow of the river at this time was 3500 cubic feet per second, or about ten times its normal flow previous to this date. This condition is of unusual occurrence; the period of high water usually occurring early in June. At no time, however, during the following season did the flow exceed that of April 18. During this period of high water the dam was subjected to a severe test, and the result of this test is what the writer desires to call to the attention of engineers.

Fig. 2 is a general plan of the plant, showing the position of the dam after the high water had subsided. The face of the dam



FIG. 6. BIG HOLE DAM. VIEW FROM DOWNSTREAM PREVIOUS TO ACCIDENT.

was built on a straight line; the plan shows the curve given it by the force of the water.

Fig. 1 shows a section of the dam through A-B on the plan, Fig. 2. This figure shows the section as built, the form assumed during high water, also the section as proposed by the writer for the rebuilding.

Investigating to ascertain the causes for this action of the dam under the combined forces acting upon it, two shafts were sunk in the crib work, one at the point marked C on the general plan.

Fig. 3 shows cross-sections of shaft at C. From this investigation it became apparent that the timbers in the crib work had been compressed along the line of pressure. The resultant pressure, from the overthrowing pressure of the water and the weight of the section of the dam, brought undue compression upon the

sections of timber exposed to it. The timbers of the cribs, at their intersections of 8 feet centers, presented a bearing surface of 100 square inches only. The resultant of pressure, at a point 60 feet below the crest of the dam, is 148 tons for one foot of section on the line A-B, Fig. 2. If the line of greatest pressure comes at an intersection of timbers, as above mentioned, and if there is nothing but the timbers to support the load, we have a load of 2960 pounds for each square inch of the surface; and, if we assume that each wall of the 8-foot crib is to carry its full load under the above conditions, we have eight times the above load, or 23,680 pounds per square inch.

The crushing strength of Montana white pine and fir lumber, from tests since obtained by the writer, is about 400 pounds per square inch for pine and 600 pounds per square inch for red fir, for about three per cent. compression of the height of blocks tested, and an ultimate load of about 2000 to 4000 pounds per square inch. (See table of tests appended.)

This result shows the compressive strength of Montana pine to be about one-third that of good, long-leaf yellow pine.

It is not to be supposed, however, that the timbers, at intersections, were intended to carry the loads shown. The cribs, being filled with loose rock and the fine material before mentioned, with the openings between the timbers filled with stone placed by hand to form what is termed a dry wall, was intended to carry the load proportionately with the timber. From observation, however, the writer is convinced that the laying of rock of irregular surfaces, in what is termed a dry wall, between the timbers of crib work, does not give bearing surface sufficient to resist the pressure under the conditions mentioned, no matter how carefully they be laid. Observations in the shafts mentioned show that the irregular surfaces of the rock, placed between the timbers, are pressed into the wood. The section of shaft shown in Fig. 3 contains 27 timbers, each originally 12 inches high, compressed into a distance of 24 feet 10 inches. The total settlement of the dam is 4 feet at the lowest point at the crest along the line of pressure. The settlement or compression, as shown in the shaft mentioned, bears its relative proportion of this 4 feet.

The compression of the timbers, with the settlement of the material in the cribs, occurred during the period of high water, from April 16 to 25. As soon as the water had subsided, alignments and measurements were taken, and subsequent high water caused no further change in the structure. The crest of the dam, as shown in Fig. 2, curved toward the downstream face, the greatest ordi-

nate of curvature being 13 feet inward from the original face line of the dam. The base of the dam remained rigid. The backward movement of the face began at a point about 50 feet below the crest height. The face planking remained rigid, and simply moved backward. The deflection from the original elevation of the face was only that due to the change from the vertical to the backward slope given it.

It is always interesting to an engineer to investigate the causes of certain results. At the instance of the company the plans and workmanship of the structure under discussion were examined by several engineers, who were well able to pass judgment upon both. The question of failure, from compression that actually occurred, was never surmised by any of them. The question of foundation was long under discussion, and great pains were taken to be absolutely sure of its stability and of its water-resisting qualities. A well-known hydraulic engineer, who assisted the writer in making an investigation of the causes of the deflection of the dam, remarked afterward that he would not have thought it possible, had he visited the work previous to the failure. The necessary weight of structure and apparent rigidity of construction were there. The structure was pronounced safe by all. Still it failed in an unforeseen way, that experience teaches can be avoided. The precedent established can be used with profit in future designs of this nature.

The writer has already stated that the compression of the timbers occurred between April 16 and 25. No absolute measurements could be taken prior to the latter date; but from the personal observation of the writer he is convinced that the action took place immediately upon the application of the load. As the water rose toward the crest of the overflow, the curve of the face increased in proportion with the rise of the water. The writer observed closely the action of the structure during the rise of the water for the last ten feet to its highest stage. The movement backward was gradual and appeared to cease when the greatest height of water was reached. The compression of the timbers, under the load applied, should produce this result, and without doubt it did so.

The filling in the dam was necessarily done during the freezing weather of the winter months. To puddle the filling was not practicable; it was intended that the mass of filling should be compact and should not settle to any great extent, as fully 90 per cent. of the filling was of broken stone. The spaces between the timbers being filled with stone and the entire body of the filling in the

cribs being quite compact, it was not thought that the settlement of the material would be of serious consequence. As a matter of fact, the material settled very little in the cribs, even with the free access of water into the structure after the flood. It had not been intended to turn the water into the crib work suddenly and in large volume. It was expected that while the reservoir was being slowly filled sufficient water would find its way into the dam to cause the fine material to find lodgment toward the base of the structure and to fill up the voids in the coarser material of the filling. It must be admitted, however, that this puddling of the material was not deemed essential as a matter of safety for the structure. The more compact the mass of filling, the greater the weight of the structure. The question of thus forming necessary bearing surface for the timber in the cribs to resist compression was not contemplated. The necessary weight of the structure was figured on the basis of loose rock filling only.

The result shows, however, that had the material been thoroughly puddled together, the voids among the stones between the timbers thoroughly filled solid with the fine material, the timbers would in all probability have had sufficient bearing surface to prevent the compression of the timber to the extent that occurred.

From the writer's observation and investigation, it is obvious to him that the supporting walls of a timber crib dam, namely, those parallel with the direction of pressure, should be solid.

This result may be accomplished by compactly puddling the entire mass of filling in the cribs, so that each timber has a full bearing for its entire length. This result can also be accomplished without the puddling process, by the use of timber blocking between the timbers of the crib. The pressure that will be brought to bear on the timbers can be calculated, and the arrangement of the timber in the walls so proportioned as to offer the proper resistance to compression. The walls need not be solid throughout their entire length; but the line of greatest pressure should be fully guarded. Timber blocking need not be used to accomplish this necessary resistance; masonry laid in mortar between the timbers will do as well and will add weight; even stone, if quarried with flat surfaces, can be so laid as to give even bearing surface for the timbers. The use of timber blocking is, however, suggested as being probably the cheapest method of obtaining the necessary rigidity, as well as possibly the surest method of obtaining a uniform flat bearing surface for the timbers of the cribs.

As an additional precaution, the writer would suggest the

use of a system of diagonal bracing within the crib work. The system of blocking between the timbers acts as diagonal bracing against the overturning pressure, but this can be further materially strengthened by a system of braces fastened to the sides of the timber walls of the cribs before mentioned. The writer is of the opinion that, had this system of diagonal bracing been used in the structure herein mentioned, even omitting the blocking as above suggested, the dam would have remained rigid in position. There would have been no partial failure. The weight of the dam was ample to resist the forces that might be brought to bear upon it to move it bodily. Had the compression of the timber been properly guarded against as above suggested, the dam would have presented an immovable body against the forces imposed upon it.

Although, as before stated, sufficient bearing surface may be obtained by a perfect puddling together of the material used in filling the cribs, the writer is of the opinion that, in a crib dam, the safest and most satisfactory results will be obtained by the use of timber blocking between the timbers, instead of any of the other methods suggested for taking care of the compression. The timber blocking can be framed into the timbers, and, by the use of drift bolts, can be made solid and unyielding against any sliding or rolling tendency. The walls of the cribs, parallel with the direction of pressure, will become a series of rigid diagonal braces under this system. This, in the writer's opinion, is absolutely necessary to secure stability in a timber crib dam above 20 feet in height.

The Canyon Ferry dam, near Helena, Mont., is built upon the same general design as the dam herein described. (See section of dam, Vol. XX (1898), p. 335 JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, May.

The dam at Canyon Ferry, however, has but half the height of the section shown in Fig. 1. The arrangement of the timbers in the crib work is the same.

The high water of the June flood, 1898, caused a similar action to take place in this structure. The writer is informed that the crest line has formed a circular arc downstreamward. The greatest ordinate of curvature, as stated to the writer, is $4\frac{1}{2}$ feet from the original line. This structure would come under the head of a low timber crib dam, and no serious results should be caused by the compression of the timber in the crib work. However, the writer is convinced that compression occurred sufficient

to draw the crest backward to its present position. The dam no doubt is now rigid, and has assumed a position of rest and stability.

Sufficient bearing surface has been attained, by the timbers crushing in contact with the stone filling, to offer proper resistance to further compressive action under the pressure that may be applied in the future.

The system of blocking herein suggested would no doubt have prevented even this slight compression and would have held the crest of the dam in position as built. The writer recently had occasion to inspect a timber crib dam built this spring. It is 40 feet high and built of round logs, surfaced where they are in contact. The slope of the faces and of both sides is $\frac{1}{2}$:1. The up-stream face is planked with two layers of 2-inch plank. This crib work is filled with broken granite and with sand or decomposed granite, puddled solidly together. The foundation for this dam is solid rock and the crib work rests upon it. A concrete toe forms a water-tight joint with the planking over the up-stream face. This structure, as it stands, is built of round logs with the filling puddled in. The timbers, however, have compressed, and the crest of the dam has a curvature downstream of about two feet at the greatest ordinate. This structure indicates clearly a compression of the timbers along the line of pressure. The dam was filled with water to the waste way at the time the writer visited it. The dam shows no tendency toward bulging backward. The base is intact; the backward movement of the crest runs out and fails to show but a short distance from the crest height.

The timbers on the back of the dam incline slightly inward, while those of the face have the same inward inclination toward the line of greatest pressure.

These instances are mentioned only as confirming the writer's opinion formed from his investigations of the behavior of the Big Hole dam during the flood.

Before concluding this paper, it may be well to refer to aprons for waste weirs. The standard form of waste weir or overflow for masonry dams is pretty well established on the Ogee or Cima form, taking the water from the crest and conducting it away in an unbroken body. This form might be adopted for high timber crib structures, but the writer has never seen a timber apron constructed on these lines. Where practicable, the flat, sloping apron accomplishes the discharge of waste water with the least disturbance, and it should be adopted when possible.

This is easily done when the dam to be constructed is not too high.

The aprons of the Big Hole dam were so arranged that the column of water passing the crest should be broken by the short aprons and strike the lower apron in the form of a broken column. The result was very satisfactory, with the volume of water passing the crest at the high-water stage this year. The writer, however, is informed that at high water in the Missouri River this season the water reached a height of 5 feet over the crest of the Canyon Ferry dam. The column of water fell on the first apron, jumped clear of the second and struck with full force on the lower apron. This apron, however, was protected by the water cushion above it, or it would no doubt have been completely wrecked by the concussion. This condition should be avoided. The water should be trained downward from the crest, caused to strike the intermediate aprons and not allowed to drop with full force at great distance upon the lower aprons. The construction of the aprons must be very strong to withstand this constant hammer. The width of the intermediate aprons above the lowest apron is not material, so long as the water is carried over the crest in such a way as to take the downward direction of the angle of the points of the aprons, which should be on the same angle or line of inclination, the object being to break the force of the water and not permit the full volume of water to strike the lower apron or any intermediate apron in unbroken column in the form of a direct waterfall.

The summing up of the writer's observations upon the construction of timber crib dams might be expressed in one sentence,—take care of compression of timber by sufficient diagonal bracing.

APPENDIX "A."

The following table shows compression tests on samples of Montana lumber, made by H. E. Smith, M.E., of the University of Minnesota.

The samples were cut from timber that had been in the water, as the object of the writer was to obtain the results on such specimens for compression across the grain.

The pressure was applied gradually. At the point called "crushing" in the table, the resistance of the wood to the crushing force became approximately constant for some little time, and then rapidly increased. It was found that the wood would not give way ultimately, even though the blocks were compressed to one inch in thickness. One block of each kind of wood was compressed to about these dimensions when under a pressure of 50,000 pounds.

TABLE OF COMPRESSION.—MONTANA LUMBER, ACROSS GRAIN.

Lumber.	No.	Size.	Area.	Lbs. Crush'g Load.	Lbs. per sq. yard.	Lbs. Ulti. Load.	Lbs. per sq. inch.
Montana Red Fir.....	1	4"x3,46" x3,46" thick.	13.84	8,000	578.0	33,000	2,167.6
“ “ “	2	“ “	“	9,120	658.9		
“ “ “	3	“ “	“	8,100	585.2	50,000	3,612.8
“ White Pine.....	1	“ “	“	5,600	404.6	30,000	2,167.6
“ “ “	2	“ “	“	5,600	404.6		
“ “ “	3	“ “	“	5,700	411.8	50,000	3,612.8

APPENDIX “B”.

CONTRACT PRICES.

Earth and loose rock excavation below water, per cubic yard.....	\$1.00
Earth and loose rock excavation above water, per cubic yard.....	.40
Power house excavation above water, per cubic yard.....	.30
Power house excavation below water, per cubic yard.....	1.00
Stone filling in crib work, per cubic yard.....	.75
Solid rock excavation, per cubic yard.....	1.00
Stone masonry cement furnished by the company, per cubic yard.....	5.70
Concrete above water furnished by the company, per cubic yard.....	4.05
Concrete below water furnished by the company, per cubic yard.....	5.88
Back-filling of earth, per cubic yard.....	.25
Lumber in place for labor only, per 1000.....	10.00

These prices include the hauling of all material necessary for the work, such as cement, lumber and iron, from the railway station three miles distant from the work.

DISCUSSION.

MR. E. H. MACDONALD.—The necessity for careful consideration of the design and construction of dams for power and storage purposes has been brought prominently before the engineering profession in Montana during the past two years. The amount of capital required for the construction of this class of structure is necessarily large, and the chances of loss, or even of financial wreck, due to failure.

As examples of large undertakings of this character, I might refer, in addition to the Big Hole dam, now under discussion, to the dams built for storage purposes by the Anaconda Copper Mining Company, near Anaconda.

The writer has read with much interest the paper presented by Mr. Parker, describing the timber crib dam constructed for the Montana Power Company, across the Big Hole River, near Divide, Mont.

A few days after the partial failure of the Big Hole dam, the writer was discussing the subject with Mr. Charles W. McMeekin,

Associate Member American Society Civil Engineers, who had examined the structure, and he at once and unqualifiedly attributed the failure to the crushing of the timber, because of insufficient bearing surface for the stresses that must have occurred; and, until the time of Mr. Parker's paper, the writer was not aware that there was any doubt as to the causes leading to the failure of the structure.

The author states that the resultant of pressure, at a point 60 feet below the crest, is 148 tons for one foot of section. I presume that by one foot of section is meant an area one foot wide and of a length equal to the full width of the dam at a depth of 60 feet below the crest. This 148 tons resultant pressure is correct under certain assumptions as to weight of material used for filling. The author seems to have assumed that his pressure of 148 tons is concentrated on an area of 100 square inches at the point of intersection of the line of the resultant, with a section of the dam 60 feet below the crest. He thus arrives at a resulting pressure of 2960 pounds per square inch of surface, and, on his further assumption that "each wall of the 8-foot crib is to carry its full load under the above conditions, we would have eight times the above load," he arrives at a resulting pressure of 23,680 pounds per square inch, or about 1700 tons per square foot, or nearly 50 per cent. greater than the ultimate crushing strength of the best granite. As a matter of fact, this 148 tons resulting pressure is distributed with varying degrees of intensity over an area one foot wide and of a length equal to the thickness of the dam at a point 60 feet below the crest. If this resultant cuts the base of the section at its middle point, we would have a resulting pressure of about 3800 pounds per square foot (assuming the thickness at this depth to be 78 feet), and on the hypothesis that one block of 100 square inches bearing surface supports an area of one entire crib, or 64 square feet, we would have a pressure of 2432 pounds per square inch, a stress more than sufficient to cause a failure of the pine blocking.

The results of the test which the author had made, in order to ascertain the crushing strength of pine and fir timber, agree very closely with the results obtained in the United States Government tests of 1880. It was here also found that fairly well-seasoned white pine would compress from 1-48 to 1-24 of its height under a load of but 500 pounds per square inch. Doubtless, when green or wet, the compression would very much exceed the maximum here given, indicating that a high degree of rigidity cannot be expected in a structure of this class.

MR. PAGE.—At our last annual meeting I asked Mr. Parker some questions in regard to the Big Hole dam, which he was building at that time. I asked Mr. Parker these questions because my experience is that engineers generally do not realize the pressure brought upon these dams in a sudden flood of water where the dam is not perfected, and it seemed to me something of an experiment building a timber crib dam like the Big Hole River to a height of 60 feet, as in this case. I would ask the members whether such a height is not unusual for a crib dam?

MR. CARROLL.—I believe the Big Hole dam of the Montana Power Company is one of the highest, if not the highest, crib dams that ever has been attempted. I believe that, if the dam had been constructed in any other way, it would have failed under the conditions of last spring. As it was, the binding of the timbers together, and the thorough settling of the filling when the water rushed into it, settled the whole thing down into a solid mass and saved its complete failure. I do not know of any construction that can show better staying qualities than the dam on the Big Hole has.

I believe the dam first moved downstream by the rolling of the logs at right angles to the direction of the pressure, thus throwing the whole structure out of equilibrium, after which a settlement took place, and the timbers, not being of sufficient strength, having only one intersection at the corners, and no supports between, cracked and crushed until the whole mass became solid. This was one of the reasons why I placed the fillers in the dam constructed for the Water Company, which not only gave a greater bearing surface to withstand the pressure and prevent crushing of the timbers, but also had a tendency to prevent any rolling motion of the logs at right angles to the pressure.

It has occurred to me recently that had the spillway of the Big Hole dam been built through the solid rock around the end of the structure, and if the spillway and fore bay had not been placed in the center, as they were, the dam would not have failed.

MR. WILSON.—Several years ago I built a crib dam some 50 feet in height, for which I was unfortunate enough to have no foundation, and which has been entirely successful, I believe. It is now in use and it was erected at a very small cost. My observations on that dam were such that I would engage to build a similar structure 100 feet high without fear of disaster. This was in Idaho, and we had limitations as to means and as to transportation, and we had to improvise almost all our mechanical apparatus. In answer to Mr. Page's question, I would say that there is abso-

lutely no doubt—certainly not in my mind, and I believe not in the minds of most of those who have had experience in timber structures—that it is the safest possible form of construction, because of the fact that when it fails it necessarily has to fail gradually. An earth structure goes in a second. A masonry dam is apt to do it, but a crib dam, with the possible settling into place of filling contained within the cribs, makes the failure practically a very gradual one. As far as the Big Hole dam is concerned, its failure is primarily due to the fact that it was cut in two, as Mr. Carroll suggests. The spillway around the side would have obviated anything of that sort, and, so far as that is concerned, I am credibly informed that, had a State engineer had supervision of those plans, the members of the company would never have been allowed to alter the original plan submitted by Mr. Fanning. That is something that has not been generally discussed; and the responsibility for the partial failure no doubt rests, not with Mr. Fanning or upon a weakness in his plans, but upon their alteration with a view to economy. The result was a sacrifice of property.

MR. BRADFORD.—What was the material under the dam where there was no bottom?

MR. WILSON.—Broken rock and earth, and of such a character that it was practically a quicksand with big boulders in it occasionally. I had to place the sheet piling,—could not drive it, and it was the most expensive and hardest work in the whole structure, because of the fact that we had no appliances. We put in a double row of boarding and puddled between with fire clay. The slope went back two to one. There never has been any leak nor any trouble. It was an absolutely water-tight vessel.

MR. KINNEY.—I was glad to see, yesterday, that, in the dam at the Ferry, they were putting in bolts about 5 feet in length and $1\frac{1}{2}$ inches in diameter, coupling together perhaps four or five depths of logs and clinching them perfectly. I think that if that had been done in the dam it would surely have prevented any rolling of the logs. They could not have gotten apart enough to turn up. It is a very simple expedient and it would have been a great help. A few of those bolts scattered around here and there would have held it together in good shape.

MR. BICKEL.—There is a solid floor in the Canyon Ferry dam and I was told that at one place, where they opened it up, some of those timbers had rolled or turned about 45 degrees.

MR. BRADFORD.—What is the life of timber in a dam of this character that is not covered constantly by water?

MR. CARROLL.—The Colorado Flume Company put in some dams on Basin Creek, I think, in 1882 and in 1891 (they were not used after that year) they were in excellent shape.

MR. BRADFORD.—Is that sawed timber?

MR. CARROLL.—No, round logs with the bark on. The logs seemed to be rotted under the bark, but not in the core. We found a great many sound logs there.

MR. WILSON.—Thoroughly protected from the atmosphere?

MR. CARROLL.—They were old-style logging dams, 12 or 15 feet high, built in the shape of a triangle.

MR. WILSON.—More as a retaining wall, with a filling between?

MR. CARROLL.—Yes, sir, about 2 feet of earth filling on water face. Of course, when the reservoirs filled, they were kept damp. The reservoirs were emptied in the winter. In that way they had the very worst treatment they could have.

MR. BRADFORD.—In 1889 I built a diverting dam of fir logs with the bark on, and in 5 years I had to remove them, as they were rotted.

MR. SIZER.—I would like to ask any of the gentlemen who have given it attention what they consider the present strength of the Big Hole dam,—whether it has assumed the condition of strength in which it is reasonably likely to sustain itself?

MR. WILSON.—I believe some additional work has been devised which adds very much to its strength. What its details are I do not remember exactly, but the base was practically added to very materially. They took off 30 or 40 feet of the top, rebuilding it from that point, and practically rebuilding the entire dam excepting the concrete, core and body as it existed when we saw it, below a point 30 feet, I think, from the crest.

MR. CARROLL.—They have also taken out the large fore bay and put in a penstock. This, I think, will materially increase the strength of the dam. I understand that much trouble is generally experienced in water plants in governing water wheels. An article in one of the engineering papers not long ago spoke of trouble arising from the fact that the water in the penstock had a movement or swish back and forth, which completely demoralized everything while it lasted. The engineer of the Big Hole Company wanted the fore bay in order to prevent that, and thought he could accomplish better results. The fore bay was the weak point in the Big Hole dam. That is where it first broke and gave way,—at the edge of the fore bay. They have been putting in a steel penstock protected by masonry, and as far as the structure

itself looks, it seems perfectly solid and as if it has finally settled. The only danger I foresee with the dam is the same trouble they had with the Canyon Ferry dam last year,—the water shooting over the top of the spillway and striking the bottom with such force as to wash it out and make a settlement there in the lower toe of the dam. I think the new incline apron at Canyon Ferry is much preferable to the steps in that regard. If they can keep the stream of water solid over the structure, there is not so much danger. It seems to me not a bad idea to make a water cushion for the overflow. They could get several feet of water to catch the overflow and I think materially reduce the chances of washing.

MR. BICKEL.—I understand there was a great deal of pounding of the dam when the water fell on these timbers, and it seemed to shake the whole structure.

THE CONSTRUCTION OF A CRIB DAM FOR THE BUTTE CITY WATER CO.

BY EUGENE CARROLL, CHIEF ENGINEER BUTTE CITY WATER COMPANY,
MEMBER OF THE MONTANA SOCIETY OF ENGINEERS.

[Read before the Society at its 12th annual meeting, January 12, 1899.*]

THE following short description of a crib dam built by the writer last year is not intended to be of any great practical benefit to the profession, except in the hope of calling forth a discussion as to the best method to be followed in the construction of similar structures. The writer claims nothing original in the design, but, from observation during and after construction, several improvements on the original have suggested themselves to him; and these ideas may be of some value to others who find themselves in a position similar to his.

The Butte City Water Company has had in the past a great deal of trouble with the annual spoiling of its stored water, and the writer has spent the last four years in trying to remedy the trouble. The cause of the trouble is undoubtedly the growth and decay of vegetable organisms, which develop during the summer months and lie dormant during the winter. The writer spent an interesting week discussing the similar troubles which they have had in Boston, and investigating the means employed at that place to remedy the evil. The Metropolitan Water Board has spent enormous sums in cleaning out the bottoms of its storage reservoirs, and in all new reservoirs now built the surface soil is removed to a depth where analysis shows not more than 2 per cent. of vegetable organisms. The good results are plainly visible in the complete records kept, though, notwithstanding the care, the writer is informed that the trouble still appears at times, though in a much less degree. The Butte City Water Company has thoroughly cleaned the bottom of its storage reservoir, but the writer believes that many of the obnoxious germs are washed in each year during the first flood waters, and for that reason has always advocated the construction of a settling basin above the present storage reservoir. This work was authorized in the spring of 1898, and the reservoir was completed about July 1 of that year.

In designing a dam for this settling basin the writer was hampered by several considerations. Masonry was too expensive; there is no suitable material in that vicinity for an earth dam, and

*Manuscript received March 3, 1899.—Secretary, Ass'n of Eng. Socs.

a rock-filled crib was finally adopted. A vertical face appealed to him as the best form from the fact that timber was scarce, and a more stable structure could be built with less timber. After the experience of the Montana Power Company's dam on the Big Hole he changed his views in this regard and adopted a sloping face.

GENERAL DIMENSIONS.

The dam is 319 feet long on the crest, including the spillway, and the crib work is 42 feet high. It is built of round fir logs, in cribs 8 feet square. The upper face has a slope of 16 feet horizontal to 39 feet vertical, the lower face 24 feet horizontal to 42 feet vertical. The water face is sheeted with 2-inch plank, laid double, and breaking joints to make it water-tight. This lining extends to bed rock in front of the concrete core wall.

A concrete core wall 3 feet 8 inches thick is built under the inner toe of the dam, extending from bed rock to about 12 inches above the level of the bottom of the crib work.

A 12-inch cast iron blow-off pipe is laid through the center of the structure, with a valve at the lower end and a crib protected by a screen at the upper end.

The crib work is 48 feet wide on the bottom and 8 feet wide at the top.

An earth fill is built on the back of the dam, on a slope of $1\frac{1}{2} : 1$.

CRIB WORK.

The cribs, 8 feet square, are of round fir logs stripped of all bark, and not less than 7 inches in thickness at the small ends. The logs were lapped at all intersections, and at every contact a $\frac{3}{4}$ -inch drift bolt binds them together. Between the logs, running in the direction of the pressure, fillers were inserted, as shown in the plan. These fillers were firmly held in place by drift bolts, and were put in to make a greater bearing surface to withstand the pressure, and also to prevent a rolling of the cross logs when the pressure was received.

At each end of the structure the logs were anchored to the bed rock when possible.

The logs forming the water face were hewn to a true surface to receive the sheeting, the lowest one being imbedded in the concrete core to form the knuckle where the slope joined the vertical sheeting of the core wall.

FILLING.

The cribs were filled with broken rock, decomposed granite being flushed in to thoroughly fill all the interstices. Great care was exercised in placing this so that every part of each crib was thoroughly filled. The material was put in in thin layers, spread by hand, and a liberal amount of water was used to settle it thoroughly and flush in the interstices. Owing to the fact that much of the excavation from the bottom of the reservoir had to be deposited below the dam, the filling could not be carried up in regular layers along the whole structure, as was desired by the writer. However, as will be shown further along, this method of filling one side first did not have any serious effect, as the whole structure settled equally when finished.

CORE WALL.

Along the inner toe of the crib work, extending to bed rock, a concrete core wall, 3 feet 8 inches thick, with double 2-inch sheeting along the upper side, was built to prevent any leakage under the structure. This concrete was made in the proportion of 5 broken rock, 3 sand to 1 of cement, and carefully rammed in place. The concrete was carried to about one foot above the base of the crib work, to support the lower log to form the knuckle of the sheeting. At the west end this core wall was carried to the top of the structure and extended to the back, as shown in the plans, to form the spillway.

The cement used was Utah Portland.

BLOW-OFF PIPE.

A 12-inch cast iron pipe extends under the dam to empty the reservoir when the water is needed in low water season. This pipe was laid on a concrete foundation extending to bed rock from the intake to the valve, and then imbedded to a depth of 6 inches in concrete. At regular intervals the concrete was increased 6 inches in width and height, to form collars to prevent leakage from forming a regular channel along it. The upper end of the pipe opens into a timber crib 4 feet square, on which an iron grating is secured to prevent any *débris* from stopping up the pipe. This crib is carried 4 feet above the bottom of the reservoir, but it can be opened at any time to sluice out when this becomes necessary. Where the pipe enters the sheeting of the core wall a collar, 6 inches thick, of neat cement is formed, by grouting, to prevent leakage around the pipe at that point.

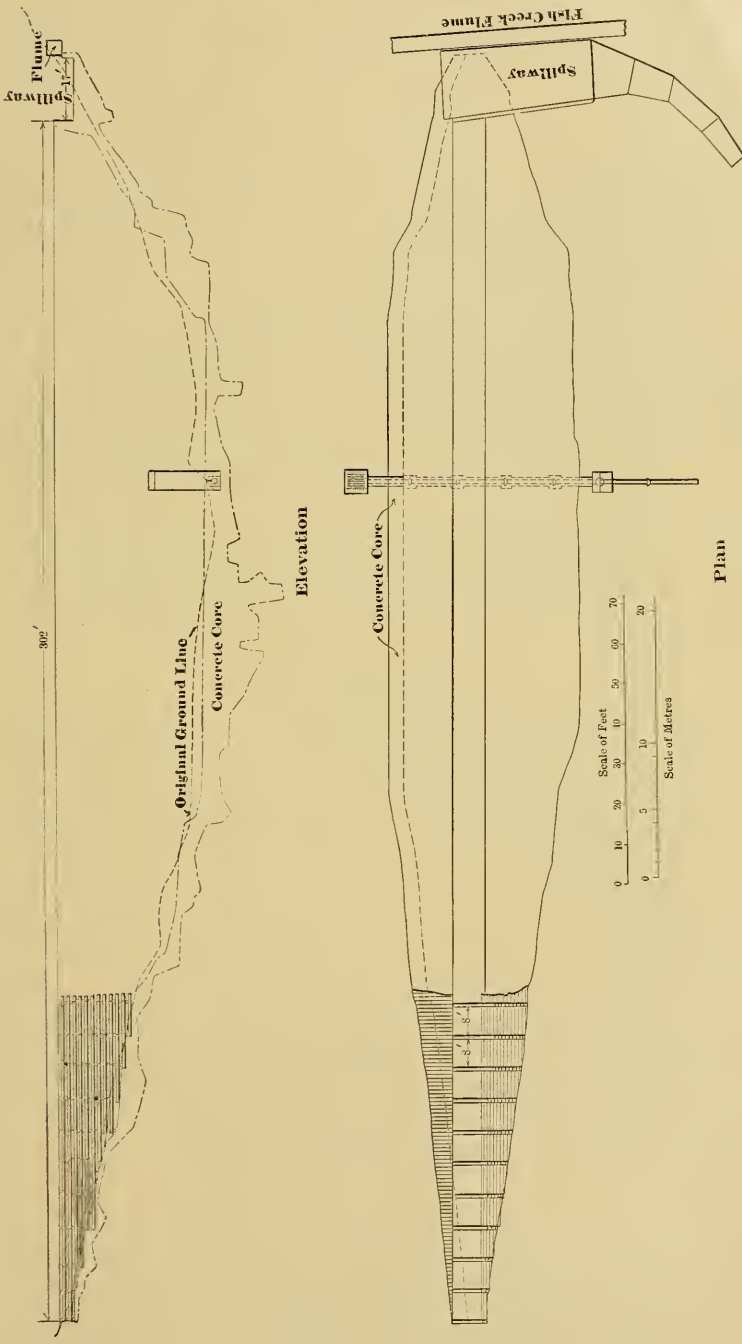


FIG. 1. BUTTE CITY WATER COMPANY'S CRIB DAM FOR RESERVOIR NO. 2, BASIN CREEK.

In addition to supporting the valve by concrete built back of it, the valve is anchored to the pipe by two $\frac{3}{4}$ -inch rods extending 24 feet back into the concrete.

SPILLWAY.

The spillway has a clear width of 17 feet, the bottom being 5 feet below the crest of the dam. It is built around the west end of the structure, and is so constructed that the overflow can be turned either into the creek or into a flume which extends from the headwaters of Fish Creek to the main reservoir below, known as the Fish Creek flume. This Fish Creek flume extends around the reservoir, and is enlarged at this point so that it can be used as an additional spillway if necessary.

The flumes and spillway are so arranged that the reservoir can be entirely cut out of the system, or the overflow can be used; or all water, including Fish Creek, can be turned through this reservoir.

The spillway is cut through a point of solid rock, which extends out beyond the west end of the dam and empties into a creek which flows into the main creek about 300 feet below the toe of the dam.

SHEETING.

The water face of the dam is protected by 2-inch planks spiked on to the crib work in two layers, breaking joints in every direction. At the knuckle where the sloping face is joined to the vertical sheeting in front of the core wall an additional plank was spiked over the joint horizontally, and all seams were carefully calked with oakum and poured with hot asphalt.

A puddled fill of earth and gravel mixed was then made against the dam, extending about 8 feet above the knuckle, and about 10 feet wide on the bottom.

The outside seams of the sheeting were then loosely calked with oakum to the top. The calking and puddling about the knuckle were left till the last, when most of the settling had taken place; and we were thus assured that there would be no danger of the joints opening or the facing settling.

BACK FILL.

As it was necessary to waste below the dam, this waste material was used to make a back fill on the lower side of the structure. This served to strengthen it, and it will also protect the timber from the action of the sun and from the danger of fire. At completion

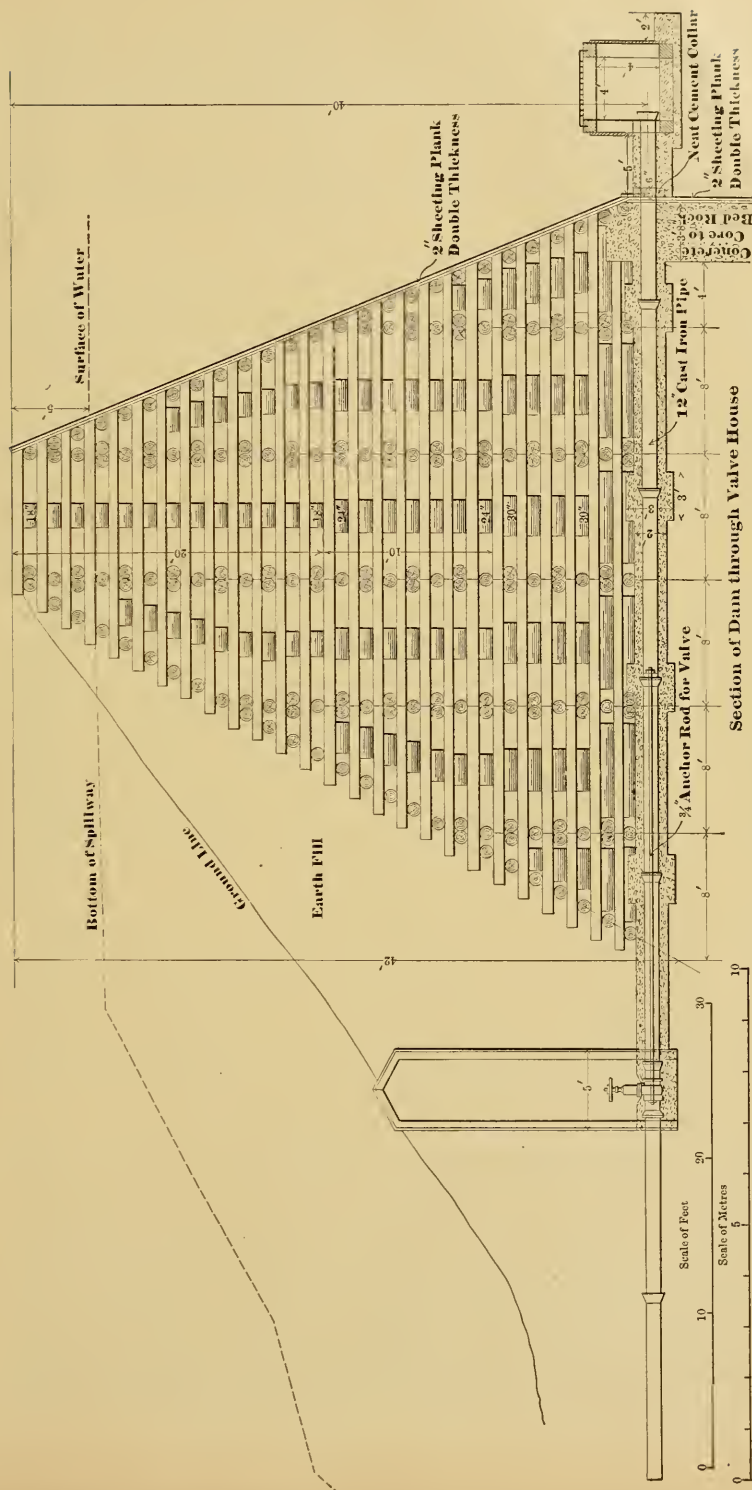


FIG. 2. BUTTE CITY WATER COMPANY'S CRIB DAM FOR RESERVOIR NO. 2, BASIN CREEK.

this fill extended only about half-way up the structure, but it was afterward carried clear to the top, partially to allay the fears of ranchers living below the structure, who were much worked up over the trouble experienced on the Big Hole with a similar structure.

A box drain is laid under the back fill to carry off any leakage through the face.

CLEANING OF BOTTOM.

All surface material was carefully removed from the bottom of the reservoir to a depth sufficient to get below all vegetable organisms. The material from the upper end of the reservoir was deposited in two draws, so as to prevent the formation of any shallow places in the reservoir. These fills were carried up on a regular 3 : 1 slope, and it is the writer's intention to cover their water slope with gravel eventually.

GENERAL REMARKS.

The matter given the most serious thought in designing this structure was settlement of the structure within itself. The foundation was perfectly solid, so that there was no fear of settlement there. The writer visited the dam on the Big Hole, and finally decided on the following changes from that design, in order to prevent a similar occurrence with this structure: Instead of butting the logs at intersections, all logs were lapped, thus giving nearly double the bearing surface at the intersections. Fillers were placed between the logs running in the direction of the pressure, not only to increase the bearing surface of the logs, but also to resist any tendency in the parallel logs to roll when the water pressure was applied. The writer believes that a sloping face is greatly preferable to a vertical one, because, as the water rises against the structure, the resultant pressure has more of a tendency to press the structure together and toward the foundation. With a vertical face there is a much greater tendency to push the structure over and to cause a rolling of the timber forming it.

The object attempted in the design of this structure was to make the timber bents, which receive the pressure of the water, sufficiently solid to hold the facing in place even without the assistance of the filling. On building this dam we had considerable trouble in placing the fillers, and I believe a better structure could be built by butting the logs running in the line of pressure and lapping the cross logs. This arrangement would give the same bearing surface at each intersection, and would bring the logs vertically one above the other, thus getting the best result from the fillers

between. As stated above, the east end of the dam was filled first, to allow a passage through the dam for the bottom cleaning and to avoid delaying the work. The east cribs were filled to a depth of about 30 feet before any filling was placed on the west end. The weight of the filling settled the structure considerably, but the writer was pleased to find that when the west end was filled that end also settled, so that there was a regular settlement from end to end, depending upon the depth, the back logs taking a regular curve from each end. When the reservoir was filled the structure continued to settle in regular form until, upon its final set, the top of the sheeting at the center was about 2 feet 9 inches out of the straight line, coming in a regular curve to zero at each end.

The logs in the back showed no sign of movement or undue strain, and all settlement seemed perfectly regular and steady throughout. On August 1, with the water within 6 inches of the overflow, the top of the dam, at the point of greatest depth, had settled back 2 feet 3 inches; while on October 1 it reached the maximum of 2 feet 9 inches.

The leakage through the face was considerable at first, but soon became less; and for the past four months has remained steady, amounting to about 30,000 gallons per day. It is the writer's intention to nail battens on the seams as the water goes down this winter, hoping thereby to reduce the leakage considerably. At some future time an earth fill will probably be placed on the water face, to keep the structure absolutely water-tight and prevent the sun from drying the facing and opening the seams each year.

DISCUSSION.

MR. WILSON.—If not disclosing any secrets, Mr. Carroll, can you give us an estimate as to what this dam of yours cost?

MR. CARROLL.—The work, with the exception of the back fill, was done by contract at the following prices: Crib filling, 75 cents per cubic yard; crib work, 12 cents per linear foot; drift bolts, 4 cents per pound; lumber in place, \$30 per thousand; concrete, Utah Portland cement, \$7.00 per cubic yard; excavation for dam and core wall, 50 cents per cubic yard; wet excavation, \$3.00 per cubic yard.

The whole structure cost, including the engineering and the back fill, about \$32,000.

In regard to the back fill, I do not claim that it is a good engineering proposition to put a fill on the back of a dam, as the leakage through the dam is liable to wash it away and give considerable trouble. It was not my intention at first to put this fill

in, but in order to allay the fears of the people living below the structure I decided to put it in partly for effect, as it makes the structure look much stronger.

There is one other good reason for placing a fill on the back of a timber structure, and that is to prevent the danger of the dam being seriously injured or caused to fail by forest fires. As the dam is in the mountains, and no one living near it, a forest fire might start at some time, and before we could get to it might seriously injure the dam, and even cause it to fail.

There is a box drain under the fill connected along the foot of the timber structure to carry away the leakage through the face.

I believe Mr. Wilson designed a crib dam something similar to this, only he placed his slope next to the water on an angle of about 30 degrees.

MR. WILSON.—In the dam I constructed the slope next to the water was two to one, and the logs were carried parallel to the face, so that practically the pressure on that face was at right angle to the courses of the logs. There was another interesting feature about the structure I built. I had an opportunity to make a fill that was very effective, and if ever such an opportunity presents itself I would earnestly recommend it. I built a dam on a stream above the main dam about 40 feet high, from which we laid a line of hydraulic pipe on the surface to a gravel bed just above the site of the main dam. By this means we sluiced the gravel in as filling, and it gave a very satisfactory result. It filled every space between the logs, and made practically a continuous blocking. The filling was so hard after it was there that I could not drive a pick into it a quarter of an inch.

MR. CARROLL.—Hydraulic dams have been built, I believe, in several places in Arizona in the past few years, running the material into the dam site by water and carrying it up in regular slopes. In our investigations during the past summer, looking toward the increase of the water supply of Butte, we found a site in which the conditions were excellent for making such a dam, and it was our intention to make it by the hydraulic method. I afterward had to abandon it, however, on account of the great depth of bed rock, which made the core wall too expensive.

For an economical dam I like the type which are being constructed in several parts of California at the present time, where a dry wall face is carried up next to the water and made water-tight by either planking or the use of asphalt or concrete.

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SEWERS LAID UNDER AQUEDUCTS AT NEWTON, MASS.

BY HENRY D. WOODS, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, January 25, 1899.*]

In the autumn of 1896 it became necessary to connect the local sewers that had been built in Newton Highlands during the summer with the main sewer coming up the Cold Spring Valley by passing under both the Sunbury River conduit and the old Cochituate aqueduct, which supply the city of Boston with water. These two structures cross the upper end of the valley on embankments with no provisions for allowing the surface water to pass under them, so that in the spring of the year considerable water accumulates at the foot of the slopes on the south side, causing complaints from the landowners that have built houses near by on the lowlands.

As eventually all the drainage from quite a district must be taken down the Cold Spring Valley, it was decided to put under the water works a culvert that would accommodate both the future drain and the sewer.

It was very important that, in carrying on the work under the Boston water supply mains, no settlements should take place that might endanger these structures, and it was not considered safe to leave any timbers in the ground under them after the work was completed, which might eventually decay and cause settlement. Mr. Desmond FitzGerald, the engineer of the Boston Water Works, who had charge of these structures, suggested the use of a long steel boiler shell or cylinder driven under the aqueduct, and

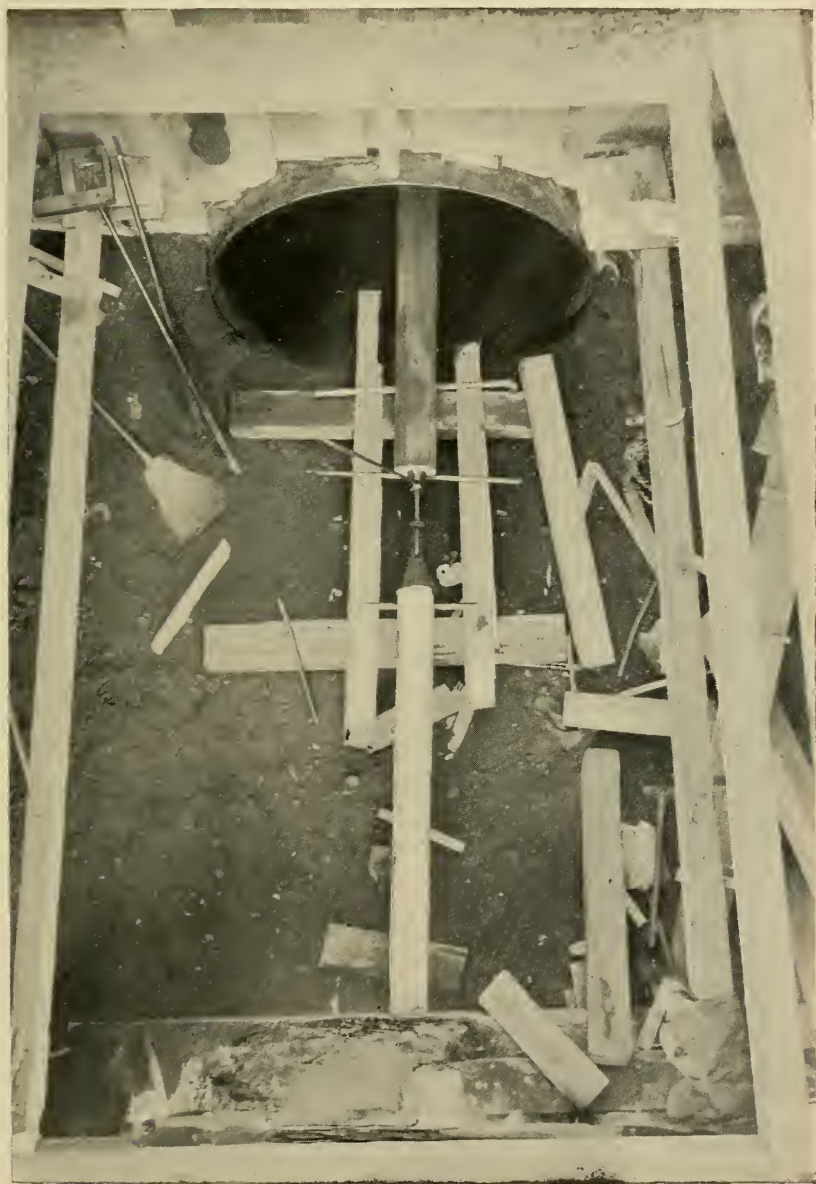
*Manuscript received April 6, 1899. Secretary, Ass'n of Eng. Socs.

it was decided to try the experiment first under the stronger structure, the Sudbury River aqueduct, which is of modern construction, of a horseshoe shape of solid brick masonry and concrete.

The brick drain required was 30 and 36 inches in diameter, and the sewer was a 12-inch pipe with 6-inch underdrain. The grades were such that a flattened section could be used on the drain, and both the drain and sewer could be placed inside a 5-foot tunnel. The excavation being in good dry gravel, we were allowed to run the open ditch to within 10 feet of the structure. This would leave 36 feet to be tunnelled. The grade of the top of the drain would be 7 feet 1 inch below the bottom of the aqueduct. Six steel cylinders were ordered of $\frac{3}{8}$ -inch boiler steel, single riveted, and from 5 feet 6 inches to 6 feet 5 inches long. The diameters varied from 5 to 6 feet, with two inches variations on each.

The flexibility of the metal was such that, when lying in the open field on their sides, they sagged an inch in diameter by their own weight. When placed in the ground, the surrounding gravel would keep them in shape, so that a circular frame or curb, made of 6 x 8-inch stock, was placed in the center of the cylinders and wedged in place so as to preserve the true shape. But, being open in the middle, it allowed free passage from one side to the other.

The regular trench was dug out 6 feet wide, but a 13-foot chamber was excavated on each side of the conduit, properly sheathed and braced, and bulkheaded towards the conduit. The largest cylinder was lowered into the chamber, an opening was made in the bulkhead at the proper grade and the cylinder was gradually forced into the gravel, horizontally, by means of a jack-screw, as shown in the cuts. The jack-screw was applied to the middle of a timber placed across the end of the cylinder by means of a horizontal 6 x 8-inch hard pine stick laid on iron pipe rolls. The jack was 18 inches long, with a $1\frac{1}{2}$ -inch screw. As soon as it had been run out some 6 inches it was turned back, more blocking was put behind it, and, if the cylinder was not going in on line or grade, the position of the block across the front was shifted so as to correct the defect. To observe any deviation from line or from grade, a transit was set up in the trench a short distance back. As fast as the cylinder advanced the material at the front was dug out and thrown back. This was coarse, loose gravel, with occasional stones as large as 8 x 10 x 12 inches, but mostly pebbles and cobbles as large as one's fist. A man was constantly watching the cutting edge, so as to fill up any openings left in the gravel back of the cylinder by dropping out of cobbles or stones. Dirt was mostly used for this purpose, except for large holes, when some



Geo. H. Walker & Co., Boston.

VIEW LOOKING DOWN INTO WORKING CHAMBER, SHOWING JACK-SCREW AND FOLLOWER FOR PUSHING STEEL TUBES UNDER THE BOSTON WATER WORKS.



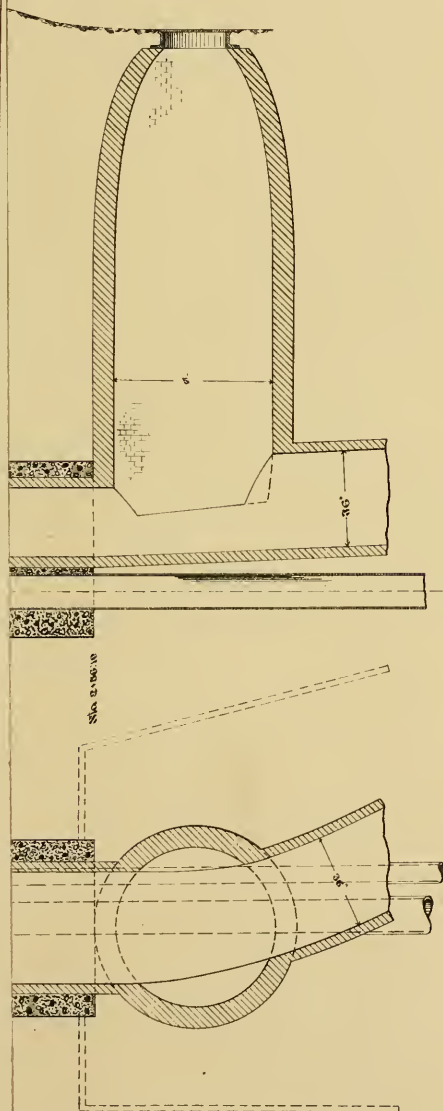
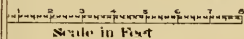
Geo. H. Walker & Co., Boston.

VIEW SHOWING STEEL TUBE TUNNEL INSERTED UNDER BOSTON WATER WORKS.

SITUATE AQUEDUCT WITH DRAIN WER AT COLD SPRING, ON HIGHLANDS, MASS.

lass,
ms.

H. D. Woods,
City Engineer.



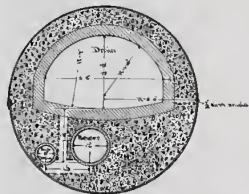
CROSSING OF COCHITUATE AQUEDUCT WITH DRAIN AND SEWER AT COLD SPRING, NEWTON HIGHLANDS, MASS.

Newton, Mass.,
Nov. 27, 1893

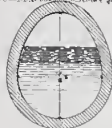
H. D. Woods,
City Engineer

Scale in Feet
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

CHISEL SECTION AT STA. 2+50.10



Water standing in the bed of former aqueduct



SECTIONAL ELEVATION



SECTIONAL PLAN

concrete was tamped in so as to leave no cavities back of the cylinder. When the first cylinder was pushed completely into the gravel the center curbing was removed; the next smaller cylinder was introduced, after trueing it up with the curb, and the jack applied to this, pushing it through the larger cylinder.

The force employed consisted of four men, one foreman and an inspector. An agent of the Boston Water Board was constantly on hand to supervise the work, and arrangements had been made to communicate with the Boston offices in case of any accident that might affect the water supply, and allow of its being shut off at once.

After getting used to the work, a cylinder was forced in place in one working day. The first one was started on November 7, and the sixth one reached the other bulkhead on the 19th. The greatest variation in line or grade at any one time was slightly over one inch. The six cylinders weighed about five tons, or 297 pounds per foot of tunnel, as the cylinders were allowed to overlap about five inches. They cost $3\frac{3}{8}$ cents per pound, or \$9.32 per foot.

All this work was in dry gravel, no water being encountered.

After this tunnel was cut through, we were allowed to try the same system under the old Cochituate aqueduct, which was known to be leaky and rather weak and shaky. A larger section was required here, on account of the drain, but the cylinders were ordered with but one inch variation, so that the diameters varied from 5 feet 6 inches to 6 feet only, and were $\frac{1}{2}$ inch thick.

The shells were made thicker, for the reason that test pits had shown that the ground water was 8 inches above the grade of the tunnel, and it was thought that there might be leaks in the aqueduct.

The Water Department intended to inject Portland cement grout through the top of the shell after it was in place, in order to fill up the interstices, and, if possible, stop the leakage. As it was late in the season, after the fill was removed from the top of the aqueduct, this was covered with manure and canvas to protect it from freezing.

The first pipe was started on November 28. Owing to the gravel being wet, some difficulty was encountered in the weight of the gravel, which tended to tip the cylinder down at the front, and more adjustments had to be made in applying the jack, so as to keep the cylinder in line and grade.

When the second cylinder was introduced, owing to their being but a single inch reduction in diameter, it was necessary to

use a steel wedge at the front, in order to keep the inner cylinder from binding in the one previously put in place.

By lowering the pump-well on the north side of the aqueduct and drawing the water into another basin, it was possible to reduce the level of the ground water in the tunnel. After this the progress was more rapid. The last cylinder was placed December 11. On this second tunnel the greatest variation from grade was 2 inches and the greatest variation in line 3 inches.

In both cases, as soon as the cylinders were in place, the pipe sewer and underdrain were put through, bedded in concrete, the top of the concrete being leveled off to receive the brick invert of the drain. This was 4 inches of brick work, which was carried clear through the tunnel.

To place the arch, work was begun in the center and run each way, on 4-foot centers, concrete being filled in outside of the brick work as fast as the work progressed.

The cost of the steel cylinders and excavating the tunnel were charged to the drain, this being the more important work. The charge to sewers was simply the cost of construction of the line of sewer and sub-drain. The cost of putting through the tunnel may be stated as follows:

	Sudbury River conduit.		Cochituate conduit.	
	Lbs.	Cost.	Lbs.	Cost.
Cost of steel shell delivered.	10,700	\$356.50	13,700	\$457.25
Cost of labor and material used in placing the shell, excavating, pumping, etc..		133.04		189.70
Total cost of tunnel.....		\$489.54		\$646.95
Length of actual tunnel.....		36 ft.		37.1 ft.
Cost per linear foot of tunnel		\$13.60		\$17.44

THE MANUFACTURE AND INSPECTION OF CAST IRON PIPES.

BY THOMAS H. WIGGIN, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, October 20, 1897.*]

It was my good fortune to spend eight months of the year 1896 in work for the Metropolitan Water Board, of Massachusetts, at two of the large pipe foundries in the vicinity of Philadelphia, and the President has asked me to present some description of the processes of pipe making and inspecting.

Methods of Casting.†

Every casting, whether a pipe casting or other, is made by one of three methods, the "green sand," the "dry sand" or the "loam." These methods are so distinct to the founder's mind that the details of making a given casting are pretty adequately described to the founder by the words "made in green sand," "made in loam," etc.

Green Sand Method.—This is the common method used for ordinary miscellaneous castings. The mold in this process is made by ramming slightly moistened sand around a pattern in a wooden or iron box or "flask." The mold surface is usually smoothed over with a mineral facing, such as powdered graphite, which largely prevents the iron from penetrating the sand, thus producing a rather smooth surface. The core in strictly green sand castings is made by ramming green sand into a "core box;" but for most castings, especially pipe castings, a dry sand, or a baked mud, or a hayed spindle and baked mud core are used with the green sand exterior mold. Such castings are still called green sand castings. Fig. 1 shows the mold for a small branch. The green sand method is almost invariably used for small castings, often for rather large ones, and sometimes for very large castings of convenient shape; but the slightly damp sand is not cohesive enough to hold together and maintain its shape in deep and complicated castings.

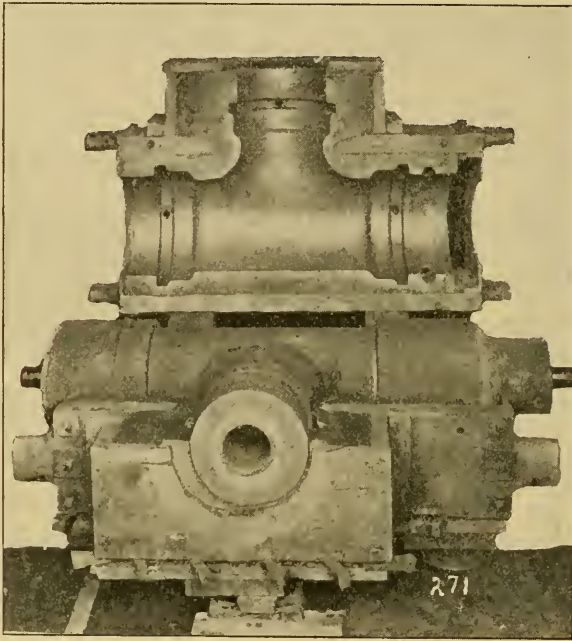
Dry Sand Method.—This method is used in moderately large and complex castings where a green sand mold would be liable to break or strain, and in general work where a more accurate shape

*Manuscript received July 18, 1898.—Secretary, Ass'n of Eng. Socs.

†The following descriptions are necessarily superficial, as molding is a science by itself.

and smoother surface are desired than are obtainable with green sand. The process of ramming the earth around the pattern is essentially the same as in the green sand method; but for the rest, there are these important differences: The earth used, at least next the pattern, is of a more cohesive nature (cohesion increased by addition of flour and clay water); the mold is rammed in an iron flask and the surface of the mold coated with a liquid blacking containing carbonaceous material, such as powdered coal and

FIG. 1.



graphite (mixed with clay water or molasses or other liquid); and the whole is baked, for perhaps twenty-four hours, in an oven of moderate temperature. The core in the dry sand method is made in dry sand, of baked mud or of baked mud over hayed spindle.

Loam Method.—Most of the largest and heaviest castings, such as are required for heavy machinery, are made in loam; also many castings that can be made without a pattern if made in loam. The loam mold is made by building up around a pattern, or otherwise, a structure of the desired shape with soft bricks, iron binding plates and mud made with clay, sand, wheat flour, clay water, etc.,

or other cohesive mixture, with some ingredient to keep it sufficiently porous. A skim coat of fine mud is put on, the surface is blackened with liquid blacking and the mold is baked in the oven, as in the dry sand method. In some cases, such as large water pipe curves, the method is cheapened by having a cast iron flask a little larger and about the shape of the object, and lining this flask with split brick and loam.

The grounds for the choice of method of molding have been very roughly indicated in the foregoing, but the method chosen for a given casting will depend on the particular circumstances, such as the smoothness desired, the fittings on hand, the number of one kind desired, etc.: and also, in a large measure, on the judgment of the founder who is making the selection. The following list gives the methods generally used in making castings for the Metropolitan Water Works. Such a list would vary somewhat for the different foundries, but the one here given is substantially correct for all:

Green sand, no core.—All caps, covers, etc.

Green sand, with green sand core.—Sleeves, 12-inch, 16-inch, 20-inch and 24-inch.

Green sand, with baked core.—All specials, 12-inch and under, except sleeves and caps above mentioned.

Dry sand, with baked core.—All straight pipes; all long (12 feet) reducers; blow-offs, 16-inch, 20-inch and 24-inch; tees, most 16 inches and larger.

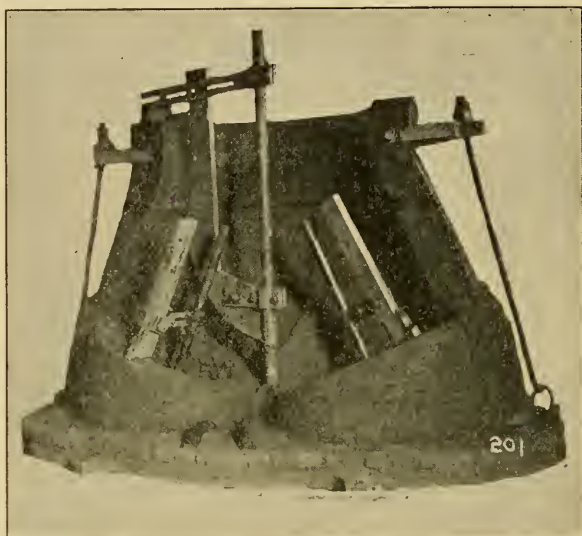
Loam.—Curves, 24-inch and larger; tees, a few of the larger; reducers, 16-inch and larger (except long ones cast in dry sand, as above noted); blow-off branches, 30-inch and larger; all manhole pipes.

Swept-up Molds in Loam.—It was stated that the loam method is used in many castings that can be made without a pattern, if made in loam. Perhaps the most important of such castings are those belonging to what are called, geometrically, solids of revolution. Now, all pipe castings are composed largely of one or more solids of revolution. Hence, molds for many of these (all of those mentioned above as being cast in loam) are made wholly, or mostly, without patterns, by the use of the sweep and the spindle. The spindle (this word is used to designate also the iron frame for cores) is usually only a straight, round bar of iron, three inches, more or less, in diameter, which is fixed firmly in the proposed axis of the mold, and serves as the axis of revolution for the sweep. The sweep consists of an iron collar and arm, with board of proper shape bolted to the arm, the board being furnished usually with an

iron cutting-edge. The collar is lowered over the spindle and turns on it. The sweep can hence be readily revolved around the spindle, and serves as a guide in placing the bricks and loam in the mold; it also serves to cut off the surplus loam and shape the surface of the mold.

The spindle for the curve is bent to the shape of the center line of the pipe, and the mold is built up as in the case of the simple castings, like reducers, only the position of the collar of the sweep has to be changed every six inches or so on the spindle. The result is not an exact curve, for, in order to produce an exact curve,

FIG. 2.



the collar would have to be changed continuously, but any apparent angles are smoothed over by hand by the molder. The chief errors in curves are caused by not bending the spindle properly to the axis of the pipe, and by not setting the spindle properly in its base. With reasonable care, large curves, such as 48-inch and 36-inch, can be made without error, in laying-angle, larger than that corresponding to about an inch of joint opening, and with but few errors larger than that corresponding to $\frac{1}{2}$ inch of joint opening. However, if care is not taken to test the curves, by template or otherwise, errors much larger and really troublesome will creep in. Fig. 2 shows one-half of the outside mold for a Y branch, with the sweeps and spindles, that were used in shaping the mold, in

position. The Y branch is rather a complicated swept-up casting, requiring three spindles; the core is made in four sections, which are afterward put together.

Straight Pipes.

Straight pipes were formerly made by the green sand method, and later with a baked core. They were cast on their sides, as many building columns are still cast, with the result of uneven thickness. Pipes are now cast invariably with their axis vertical, and, with the exception of a few small pipes, are cast with the heads, or bell ends, down.

The enormous use of cast iron water and gas pipes has caused the development of a highly perfected system of making molds, in which labor is reduced to a comparatively small amount. The mold is divided into a number of easily-made parts, each one of which is made by an individual, or by a gang, specially trained to make it. In short, the same specialization is applied that is universal in other factories where large numbers of one article are made.

THE MOLD.

The arrangement of the mold is shown in Fig. 3. On the left is seen, in half section, the arrangement for casting bell down, and on the right the arrangement for casting bell up. A is the "flask," consisting of a cast iron casing for the mold. It is made in sections for convenience in making and handling. The flask is lined with sand by ramming around patterns. A sectional iron pattern is used (in the bell down method) to form the bell shape, and a turned cylindrical iron pattern is used to form the barrel of the pipe over. This iron pattern has to be of a diameter equal to the outside diameter of the pipe, plus double the thickness of the coat of blacking, plus the shrinkage of the pipe; and it is evident that a new or altered pattern is necessary for every noticeably different outside diameter of pipe.

The chill B (Fig. 3) is a cast iron machined ring, which is the foundation of the whole mold, and holds the parts accurately concentric. A small channel of earth under the face of the bell prevents the iron of the latter from being chilled, and thus serves to make the name "chill" a misnomer.

The spindle C is an iron cylinder fitted with a bearing at each end, and serves as the rigid frame for the core. E is the hay rope which forms the first layer of the covering for the spindle.

D is an iron ring called the "socket ring." The socket ring serves as the basis of the socket, which is made with hay and earth, as shown. A chain ring is often incorporated into the top of the

socket earth, to strengthen it against the shock of falling iron. It will be seen that the socket ring fits by a machined bevel and shoulder into the chill, and that the rest of the core fits into the socket ring.

At the top of the mold is the "bead ring" F, which forms the end of the pipe and the top half of the spigot bead. In the bead ring, on the edge next the core, are the six to a dozen semi-circular nicks through which the iron flows into the mold, and also the single nick, "riser," through which air and gases escape when they are displaced by the entering iron. The bead ring is made by pouring a semi-fluid mud, made very strong by liberal use of clay water and wheat flour, into an iron mold and baking it. An iron ring is usually incorporated into the bead ring to give it strength. The trough of sand resting on top of the flask is the "runner" into which the molten iron is poured.

CORE MAKING.

The iron spindle, hot from a pipe recently cast, is placed on two bearings and revolved by power transmitted through gearing similar to, though much rougher than, that in a metal-working lathe. First, twisted hay rope, made at the foundry of salt hay, is wound on. Then mud, or mully, made in a pug mill, and consisting of a mixture of argillaceous loam, sand and water, is applied to the hay rope. A true cylindrical shape is obtained by the lathe process, though the tool, unlike the lathe tool, is long enough to act on the whole length of the object at once. This tool, called the strike, consists of a plank with a straight edge, bound with iron, set and wedged at the proper distance from the center of the spindle. The first coat of mud brings the core to within perhaps half an inch of the final radius. The core is then baked over night, after which it receives the skim coat of a finer, more sandy material, and finally a coat of liquid blacking.

The common way of putting on this blacking, namely, by hand with a broad brush, destroys, to a large degree, the value of the smoothness of the skim coat of mud. The random arc-shaped ridges, covering the inside of the pipes, are often attributed to the tar coating. As far as my experience goes, nearly all the marks in water pipes are in the iron, not in the coating, and most of them can be attributed to the method of putting on the blacking. The ridges are not measurable by putting on a carpenter's rule, but it seems probable, in the light of our knowledge of the important effects of tubercles, that these marks do cause an appreciable loss in flow of clean pipes. They can be largely avoided—and they have been avoided in some cases—by smoothing the blacking by

the strike, in the same way as the mud surface is smoothed, though the labor and the risk of breaking the core are thereby somewhat increased. The change would probably not be discoverable in increased cost of pipes.

The core of a 48-inch pipe is made about a quarter of an inch larger at the bottom than at the top, in order to allow for the compression caused by the twelve feet of molten iron.

UNIFORM OUTSIDE VS. UNIFORM INSIDE DIAMETER, FROM THE FOUNDER'S VIEW.

To vary the inside diameter of a pipe is a very simple matter, requiring only the insertion or removal of one or more strips of brass at the ends of the strike. To vary the outside diameter, on the other hand, requires the construction of three new turned iron patterns: viz, a sectional one for the bell, a pattern for the socket and a long, turned cylinder for the barrel of the pipe; unless the founder happens to have apparatus on hand near enough to the required dimensions to pass the inspector, who, fortunately for the founder, usually has less respect for small dimensions, such as quarter inches, than the engineer is apt to have. The founder looks forward to the happy day when a constant outside diameter and uniform bell and lead-score designs shall rule throughout the pipe-using world. As far as convenience in making joints is concerned, the engineer must agree with the founder that uniform outside diameters are very desirable.

THE IRON.

The iron is melted in the ordinary cupola. Coke is generally used as fuel, and oyster shells or limestone are used as flux. The proportion of fuel to iron is, for a rough average, about one to eight by weight. A new fire is started each day, the cupola bottom being dropped at the end of the pouring. The remnants that are dropped from the cupola at the end of the pouring, containing some shot-like pieces of iron, some larger pieces of partially melted pig and a good many cinders, are run through a revolving cinder mill, which separates the iron from the cinders. The iron thus obtained, "shot iron," though containing, like cinder iron, an extra proportion of impurities, is worked into the charges in small quantities. Rejected castings also are used in the cupola after being broken up, and gates, risers and runners, of which a large weight is cast daily, are utilized in the same way. The runner of a 48-inch pipe will weigh about 500 pounds, say six per cent. of the weight of the pipe itself, and, of course, is not to be thrown away unless under compulsion.

Sometimes the founder gets too hurried about working in his scrap iron and gets more scrap still by bad castings. Scrap begets scrap, unless it is carefully used. In the modern chemical methods of mixing iron, however, the scrap iron and cinder iron are no longer considered as always undesirable, but have their proper uses in obtaining required chemical composition. Iron of a given composition is identical, whether it is obtained by the use of scrap or by the use of pig.

POURING.

The iron is tapped from the cupola into a pouring ladle holding, in straight pipe work, from three to six tons. If the iron is thought to be too hot,—*i.e.*, hot enough to injure the mold,—it is either allowed to stand until cool enough, or cooled down quickly by the addition of scrap iron or pig. The ladle is then skimmed of dross, and a little earth is thrown in on the iron near the nose of the ladle, forming a cake which acts as a dam to keep back newly-formed dross.

Two methods of pouring are used for large pipes. One is to pour the iron directly into the runner and allow it to fall to the bottom of the mold; the other is to begin pouring through what is called the main gate, or side runner, a sand-lined passage about $1\frac{1}{4}$ inches in diameter, leading from the top of the flask to an opening into the bell cavity, in order to prevent the iron from falling 12 feet or more on to the shoulder of the socket, which obviously has to stand the shock of the iron so falling in the method first described. By the second method, iron is poured through the main gate until the metal stands above the socket, when the main gate is plugged and pouring goes on as in the first method. Advocates of the simpler first method claim that, by the method of pouring at first from the bottom, a cool scum is formed on the iron which has come slowly in through the main gate, so that the iron afterwards coming in at the top does not unite perfectly with the former, causing a partial cold shut just above the socket. The two methods are apparently used with equal success, and the simpler method of pouring wholly from the top is the one most commonly used.

The principal point to observe in pouring is to keep the runner full, so that the scum will float in the runner and not be allowed to get through the gates.

VENTING MOLDS.

When red-hot iron comes in contact with a mold a large volume of steam and other gases is formed, and must have means of rapid egress. Air and other gases, displaced from the mold cavity

by the iron, escape largely by the "risers," or open holes similar to gates, left in the top of the mold as passages for escaping gases. But gases are formed in the material of the mold, and in pipe molds egress is provided for by having many holes in the flask and in the spindle. The gases burn with a blue flame at these vent holes during and after pouring.

As the escape of gases must be provided for, the founder is careful not to use molding earth of too compact a texture.

PULLING THE SPINDLES.

After the pipe has been poured, the mold, with the contained pipe, is allowed to stand for perhaps twenty minutes. Then the spindle is hoisted out. In this connection the use of the hay rope in the core is best explained. The hay rope is sufficiently firm to hold the metal in place until it hardens, but it is sufficiently yielding to allow the pipe to shrink as much as it will in cooling to a self-supporting state, without binding the spindle immovably in place. If no cushion of hay were put between earth and spindle, the pipe would either shrink immovably onto the spindle or perhaps burst. Even with the hay rope a pipe is occasionally allowed to cool too long before the attempt is made to withdraw the spindle, with the result that the spindle is bound in inextricably for the time. In such cases, after the pipe is cool, the hay and earth are laboriously cut out with a long, thin saw.

TURNING OUT THE PIPES.

The pipes are usually allowed to stand in the flask until fairly cool, often over night. Small pipes, however, 16-inch and under, are often turned out while still red, which perhaps may cause them injury by sudden cooling. At any rate, enough of them crack in handling to give credence to such a theory, in the absence of comparative records of pipes turned out hot and pipes turned out cold.

CLEANING THE PIPES.

The pipes come from the casting pit with iron socket ring in bell, all the core earth inside the barrel (the hay has all been burned out in a grand conflagration occurring when the spindle is removed) and with gates and fins projecting. It is a day's work for about four men to clean away the dirt and chip off the fins and gates from, say, fifteen 48-inch pipes. If the pipes are scabbed, it will take much more labor.

INSPECTION.

After the castings are cleaned the inspector goes over them and decides which are all right, which will be acceptable if their spigot ends are cut off and which are too imperfect for acceptance.

The inspectors are usually hard-headed, practical men, and a large proportion of them have grown up in foundry localities, have been employed in foundries previous to becoming inspectors and hence know the imperfections to which castings are liable, though their knowledge of metallurgical chemistry is slight. As far as the writer observed, the inspectors are absolutely fearless and unswerving in carrying out their convictions or their instructions.

The writer was told by a founder that the causes leading to imperfections in castings have been numbered above a hundred. The practical imperfections in pipes, however, can be reduced to a smaller number:

1. Mistakes in dimensions, due to inaccurate measurements of patterns, wrong setting of strikes for cores (losing a brass, for example), etc. These are rare after an order is well started.

2. Too small diameter, due to abnormally high shrinkage. This occurs rarely, and only with large pipes.

3. Scabs. A scab is caused by the coming out of a piece of the mold. An irregular excrescence on the pipe is thereby caused. But this does no harm in itself. The excrescence may be chipped off, unless so large as to require too much labor. The objection to scabs consists in the uncertainty as to what has become of the dirt which broke from the mold. It has floated off up into the pipe, and may be lodged under a thin skin of iron somewhere in the barrel of the pipe. If it is evident that the dislodged earth has floated to the top of the pipe, then the top of the pipe may be cut off and the rest of the pipe considered good. If it is uncertain where the dirt went to, then it is the part of prudence to reject the pipe, if the scab is of considerable size.

4. Mold-cut. A mold-cut is caused by the iron penetrating the mold and partly including within itself a piece of mold. The dirt does not float away, but remains partly in sight. The mold-cut, if of considerable size, is fatal.

5. Socket-cut. This is a mold-cut in the socket, caused by the iron getting between the earth and the metal ring. It is usually fatal.

6. Dirt fallen in by accident when the runner is made. There is usually a little of this, occasionally enough to show, and sometimes probably enough to cause unseen damage, because, unlike the scab, this dirt leaves no tell-tale excrescence to show its presence.

7. Core-swells and core-strains. Sometimes the core is not firm enough and becomes distorted. This shows in the inside of the pipe and sometimes causes rejection. A skilled inspector told

the writer that a more important and more insidious injury than uneven surfaces was sometimes caused by core-strains. A core might continue to give slowly after a crust had been formed all around the pipe and the gates had become too hard to admit more iron. The result was that the molten iron settled down, leaving invisible cavities between the shells at the tops. The writer has seen hidden cavities 4 inches square and $\frac{3}{4}$ inch deep found in the tops of 48-inch pipes. They occurred at the gates, and were called "gate-shrinks." Whether such cavities are due to core-strains, or to simple shrinkage, or to both causes, it is obvious that the gates should be kept open to supply iron until danger of cavities is past. At one foundry it was the practice to keep the gates from freezing, for perhaps one minute after pouring, by the use of a poker.

8. Scale. Occasionally founders are troubled by a continuous run of scale, the cause of which the writer has never heard explained. A thin substance appears in blotches, sometimes a yard square and perhaps one-sixteenth of an inch thick, on the inside of the pipe. It appears to be partly of metal, adheres strongly, though not immovably, to the pipes, and, when removed, usually leaves a little shoulder where it fades into the clear iron.

9. Imperfect spigots. Imperfect spigots may be due to several things, such as shrink-holes, dirt, dross, check cracks, etc. The top end of a pipe is the catch-all for the dirt, dross, etc., that may be in the iron, and for dirt from the scabs, etc., for all these impurities are lighter than iron and tend to rise to the top. The remedy for it all is to cut off the imperfect part, and, in castings of which it is important to have the ends clean for facing, etc., it is customary to cast on an extra top, or "shrink-head," so called, to collect all the impurities. This shrink-head is then cut off, leaving a clean casting. Imperfect bead ends are by far the most common defect in pipes. The cut pipe is objectionable for several reasons: (1st) its length is uncertain, so that it cannot be calculated on; (2d) it is shorter than standard and increases the number of lead joints in pipe lines; (3d) the wrought iron bead, which replaces the cast iron one, is apt to come off, though this is unlikely, if a *rectangular* channel is cut around the pipe for the bead ring to rest in.

10. Shrinkage cracks. These are comparatively rare, and usually short. They are sometimes found around the bell, sometimes at the spigot end.

11. Underweight and overweight. If a pipe is below a certain fixed minimum weight the inspector cannot accept it. If it

is above a certain weight the inspector has no objections to taking it, but the founder will then be giving away some iron. Hence, sometimes the founder keeps the overweight pipes for stock.

12. "Out of round." Occasionally a flask will so behave as to distort the pipe, presumably changing its shape after the spindle is removed. The reason is not clear; the fact is stated on the assertion of founders.

13. Uneven thickness. This may be caused by the misplacing of the core, in which case it will show at the ends, or by failure to pull the pattern in a straight line while ramming the mold. Uneven thickness may be discovered by caliper measurements, but most easily by watching the rolling of the pipe on smooth, level skids. The heavy side will go down rapidly and tend to stay down. This is a rare defect in pipes cast vertically. All know its frequency with horizontal core-castings.

14. Unsuitable iron. The inspector judges whether the iron is soft enough to cut and drill, not cold-short nor red-short, and generally clean. Rarely he rejects ladings for too hard or too brittle iron, supposed cold- or red-shortness or general dirtiness; but, as a rule, any perfectly-formed casting passes muster. The methods used in the attempt to judge of suitability of iron will be described presently.

15. Leaking or bursting in press. Sometimes a pipe will develop leaks in press, usually near the spigot, and caused by dirt, dross, etc.; and less often a pipe will actually burst. Twenty-two out of 14,500 pipes, the records of which the writer studied, burst in press, and there is no telling whether some of these had not been previously injured in handling.

16. Cracked in handling. This requires no explanation. Many pipes are found cracked after receipt by the purchasers.

Some figures on rejected, burst, cut and split pipes are given in Tables I and II.

The inspector goes over each pipe carefully, pecking it strongly all around the spigot end, inside and out, and at any other doubtful points, measuring the thickness at the ends with calipers, rolling the pipe for uneven thickness, and judging whether the iron can be drilled and cut. Special castings are examined with equal care, and all anchors are carefully headed over to prevent leaks. In fact, the inspector, backed by the modern cast iron specifications, holds the founder up to the highest pitch in workmanship, which he is able to reach by accepted methods and apparatus.

COATING.

In this connection the common method of coating pipes* will be described. Further on the question will be discussed somewhat, in the light of a number of experiments tried for the Metropolitan Water Works.

The inspector having passed judgment on the pipes, they are rolled along down to the coating apparatus. The apparatus consists of a number of ovens, with iron cars, on which the pipes are rolled into the oven and on which they stand during heating, a vat or tank for the coating compound, a crane for hoisting the pipes in and out of the vat, and various brushes, scrapers and mops for brushing out dirt and removing surplus coating material. The coating material is crude gas tar with sometimes some dead oil of tar added. The pipes are given a fairly good brushing before being put in the oven. The oven is merely an enlarged chimney flue, for all the smoke and gases of combustion pass in at one part and out at another, so that a light, but visible deposit of soot is made on the pipes, which is not brushed off. The old-fashioned ovens have simply a square hole through the floor of the oven connecting it with the fire, so that the hot gases, and occasionally flame, act principally upon one portion of the pipe, heating that portion very hot before materially affecting the other portions. The newer ovens are fitted with an arched bottom, with bricks left out at intervals all along the pipe, this arrangement causing a more uniform temperature. The pipe is left in the oven until the attendants think (no thermometer is used) it is heated to about the correct temperature (48-inch pipes are left in about 20 minutes); then it is put in the tar to stay from a moment to 10 minutes, according to the condition of the work about the vat. On being removed from the vat, the pipe is allowed to drain over the vat, and the drainage is aided by scraping the invert with a segmental hoe, made to fit, or at least to be of smaller radius than the pipe. The pipe is then lifted out onto the skids and the coating smoothed up further—surplus tar removed and thin places reinforced—by a brush or a mop. The brush is better because the mop leaves part of itself behind on each pipe. The coating becomes hard in from $\frac{1}{2}$ to 2 hours, according to conditions.

WEIGHING.

The pipes are now passed over a set of platform scales and weighed. The inspector witnesses the weighing and also the

*Gas pipes, of course, are not coated; moreover, a few cities do not have their water pipes coated, as their water does not act much on cast iron.

painting of the weight, class and number on the inside of the pipe, in white lead.

PROVING.

The next step in the life of a pipe is to be proved,—*i.e.*, subjected to hydraulic pressure. The pipe is placed between two heavy discs, one of which is stationary, and the other of which is attached to the piston of a hydraulic cylinder. Proper gaskets are placed between the ends of the pipe and the disc, and the hydraulic press squeezes the pipe and gaskets firmly between the discs, thus closing the ends of the pipe. Water at low pressure is then let into the pipe through an orifice in one of the discs, and the air in the pipe is forced out through another orifice at the top of the pipe. It is important to have practically all the air out of the pipe, as the expansive force of the air is liable to throw fragments of pipe in case of bursting. If there is no air present the bursting of a pipe is very quiet. When the pipe is filled with water, the air valve is shut and water at high pressure is turned on. The high pressure shuts off the low pressure by a check-valve, and the pressure is run up usually to 300 pounds, and held until the inspector is satisfied. The inspector makes it a point to hit the pipe several blows in different places, while the pressure is on, to aid in the development of incipient cracks.

As already noted, the number of pipes burst in press is very small. The reason is not far to seek. The pipe of the M. W. W. schedule, which (barring the 54-inch and 60-inch pipes) would be subjected to the greatest tension per square inch, at 300 pounds' pressure, is the 48-inch, class A, having a thickness of 1.15 inch. The theoretical tensile stress in this pipe, at 300 pounds, would be $\frac{300 \times 48}{2 \times 1.15} = 6260$ pounds per square inch. Now it is very weak iron that will not stand 15,000 pounds per square inch, which would give a safety factor of 2.4 if the iron were homogeneous. The fracture in press should probably be ascribed to defects such as shrinkage or other cracks existing before proving. It is conceivable, however, that an occasional pipe may be sufficiently hide-bound to cause its own fracture in press.

When the pipe has successfully borne the hydraulic test, the inspector allows his initial to be painted in the pipe. He is then through with the pipe, and it is placed ready for shipment.

The foundries which the writer has seen are so laid out that the course of a pipe from process to process is on a gentle slope. This makes handling easy.

Tests for the Iron.

There is one important matter in the inspection of cast iron pipes which is generally thought to need more reliable judgment than the practical inspector is able to pass by the aid merely of his sense of sight, of touch and of hearing; and that is, the matter of suitability of the iron in the pipes. Perfectly-formed pipes can be made of iron of widely varying grades, may all pass the inspector, and perhaps all give fair satisfaction; but some of the iron will be more suitable than the other, and it seems reasonable that some attempt should be made to get the better iron. A description of the tests used by the Metropolitan Water Board will be prefaced by a simple *résumé* of the subject of practical testing. These properties of cast iron which the engineer must chiefly scrutinize may be roughly named as follows:

Strength.

Hardness.

Durability.

Strength is here used in a very broad sense to include resistance to injury against single and repeated, gradually-applied loads and shocks. The ability to bear shock involves the elastic deformation of the material as well as the ability to bear stress, but all is included in this rough heading—strength.

In hardness is included the capability of being cut, drilled, filed, etc. Durability is used with reference to chemical agents, durability under repeated stress being included in strength.

These properties are desired in varying degree according to the purpose for which the iron is to be used. For machinery castings ease of machining is often treated as the prime requisite. For pipe castings, strength and capability of being cut and drilled are usually considered of paramount importance. Some engineers have preferred hard iron because of its durability against chemical agents existing in earth and water, but the matter of durability is usually neglected.

It is too commonly thought that iron is divided into two classes,—viz., good iron, having all desirable properties, and bad iron, deficient in these properties. Every kind of iron has its sphere of usefulness, and no iron can be best for many different purposes.

The problem of the founder in supplying iron of desired properties is well summed up in the following words on choice of iron for a casting: "For most purposes is needed an iron which (1) shows a gray fracture, (2) forms no finery scum, (3) is easily worked by chisel and file, (4) fills the mold even to the thinnest

sections, (5) chills with a smooth surface, (6) has moderate strength, (7) is free from blow-holes, (8) shrinks but little. These conditions are well filled by an iron containing, after melting and casting,

Carbon,	3.5 per cent.
Silicon,	1.5 to 2 per cent.
Phosphorus,	not over 0.7 per cent.
Manganese,	as little as may be (unless chill is desired).
Sulphur,	a trace.

"When such a mixture has been obtained variations may be made. For large castings, lower the silicon; for small castings, increase the silicon. If shrinkage is to be avoided, lower the manganese. If much strength is required, lower the carbon, silicon, manganese, and avoid phosphorus. If resistance to chemical action is required, make manganese as high as brittleness will allow."*

It is evident that the desired properties tend to conflict with each other. Thus, strength conflicts with the *highest* chemical durability, though strong, close irons are more durable than weak, open irons.

I. DIRECT TESTS.

The direct method of determining the ability of the metal in a casting to be tooled is to *try* it by chisel and file and pointed hammer. The direct method of testing strength is to subject the casting to stress. At about the middle of this century the practice prevailed somewhat of testing, to breaking, one cast iron girder picked at random from a lot, in order to judge of the suitability of the remaining girders.† This is decidedly the most direct test possible, though it still is not a test of the very castings to be used. The ordinary method for pipes is of course to test by hydraulic pressure, but *not* to breaking, the test pressure being kept safely below the breaking pressure, as fully described on page 223.

Almost all tests for strength are made with single, gradually-applied loads, and the assumption is then consciously or unconsciously made, that the iron which will best bear such tests will also bear repeated loads and shocks incident to actual use. The assumption seems a reasonable one when both strength and stretch are considered in testing; but it was not a true one when strength

*Professor R. H. Richards, Mass. Inst. Technology. "Notes on Metallurgy of Iron."

†See Report of British Commissioners on Iron for R. R. Structures, 1849, p. 297.

alone was used,* and it is not necessarily a true one in either case. Who can say positively, for example, that the high per cent. of Foundry "Z" 16-inch and 20-inch split pipes (see lines 50 and 51 of Table I) is not due to a weakness of the iron against single or repeated shocks, though it is very strong and elastic under gradual loading?

Impact tests have been used to determine the ability of iron to bear shocks, and perhaps such tests would still be of advantage, as it is shock that breaks most pipes.

There can of course be no direct test except use for the chemical durability of iron under circumstances existing in use.

2. INDIRECT TESTS.

(a) *Appearance.* The simplest and most common indirect test is examination of fractured section, where "fins" and "gates" have been broken off. The efficiency of this method depends wholly on the experience and memory of the observer, and this experience depends on direct tests previously made. Iron of a certain appearance having been found satisfactory in the past, by practical tests and use, it is assumed that all iron of the same appearance has the same good qualities.

The most striking peculiarities of texture are quickly learned. Thus, fine, gray texture is soon associated with strength, coarse crystallization and much graphitic carbon with weakness, and white color with hardness and brittleness. The closer distinctions are more difficult to make and more uncertain.

(b) *Test Bars.* The first conception of a test bar was doubtless that of a cheap, easily-tested *sample*, as nearly identical in properties with the larger casting with which it was cast as are samples of tea or wine with the larger quantities of those articles from which the samples are taken. Hence, testing the specimen was considered equivalent to testing the casting itself. As early as 1849, however, experts realized the difficulty of getting true samples of cast iron. A British commission, of which Captain Henry James and Eaton Hodgkinson were members, reported,† "The strength of a bar 1 inch square should not be taken as the unit for calculating the strength of a larger casting of similar metal, although the practice of doing so has been a prevalent one; for it appears that the crystals in the portion of the bar which cools first

*High strength alone, without high stretch, is often found with very brittle iron. The old tensile tests did not furnish any safeguard against brittleness, as stretch was not observed.

†Report of British Commissioners on Iron for R. R. Structures, 1849, p. xv. See also p. 251.

are small and close, whilst the central portion of bars 2 inches square and 3 inches square is composed of comparatively large crystals, and bars of 3 inches square, planed down on all sides alike to $\frac{3}{4}$ inch square, are found to be very weak both in transverse and crushing pressure. Hence it appears desirable, in seeking for a unit for the strength of iron of which a large casting is to be made, that the bar used should equal in thickness the thickest part of the proposed casting."

This lack of uniformity in castings poured from the same "bath," and the same lack of uniformity in different parts of the same casting have long been well recognized, and assigned to influence of *rate of cooling* on the complex crystalline material called cast iron. The effect is almost invariably evident in a fractured surface of cast iron, the most pronounced case being that of chilled castings, in which the chilled portions are white iron, while the remaining portions are often ordinary-looking gray iron. In a recent work* on iron these words may be found: "Slow cooling, in large, thick castings, tends to increase precipitation of graphite, making very soft castings. Quick cooling against a chill iron surface, and less so in a very small casting, tends to high combined carbon and great hardness." And again, "The effect of size in a casting is to retard the rate of cooling, if large, and accelerate it, if small; the quicker a metal chills, the finer the graphite will be." This effect of size of casting is brought out, sometimes strikingly, by a comparison of a fractured section of heavy pipe with the section of a test bar cast from the same "bath." In many cases no points of resemblance are apparent, and in fact there are no points of resemblance in physical properties. The bars cut from pipes (see lines 9, 10, 21, 22, 32, 33 of Table I) show how different is the iron in the pipes from that in the test bars.

Notwithstanding these facts, the test bar of constant size has been used for many years, and has usually been considered as a fair sample of iron, whether castings are large or small.

Test Bars as Quasi-Direct Tests. When the bar is of such thickness† relatively to the casting that its rate of cooling, and consequently its texture, approaches closely to that of the casting, the bar would seem to furnish a rough direct test.

Test Bars as Wholly Indirect Tests. To Mr. W. J. Keep, of Detroit, Mich., Mem. Am. Inst. Min. E., is perhaps due the idea of using test bars as wholly indirect indications of the quality of

*Prof. R. H. Richards, Mass. Inst. of Technology. "Notes on Metallurgy of Iron."

†See pp. 235-6, also 242-3.

iron. Mr. Keep has advocated a system* of "relative" tests, including transverse tests (under both gradual loading and impact), and tests of fluidity, shrinkage and chill. In Mr. Keep's system, the tests are used, not as direct measures of the strength or elasticity of irons, but as a means of comparison of irons, a sort of mechanical analysis. Mr. Keep's system was designed to meet the need of foundries for a cheap, quick way of determining how the iron from the cupola varied from day to day, and how to modify the charging in order to maintain desired properties. Mr. Keep has used the system very successfully in the conduct of the Michigan Stove Works.

The use of the test bar as an indirect test, carried to the ultimate extent, may be illustrated by the following supposed case: From a certain bath of cast iron some castings of a certain thickness are made, and some test bars. The bars are tested and give certain results; the castings are put to use and are found of satisfactory strength, workableness and durability. More castings like the first are now desired, and the engineer specifies that similar test bars of the new iron shall be able to stand the same tests as did the former bars, believing that he is sure to get as suitable iron as was obtained before. This action rests on the assumption that the new castings are sure to be like the old ones, provided the new test bars are like the old ones, though, in either case, the metal in the bars is not like that in the castings, owing to different cooling. The safety of the assumption depends on the number and character of the tests used for the test bars. Mr. Keep uses a number of tests as above noted. Any single test is unsatisfactory. For example, the tensile test of 1 x 1-inch bars, which has been used so much, does not furnish any satisfactory identification of iron. Irons of widely different characters can have the same tensile strength in a 1 x 1-inch bar. If the stretch also were measured the identification would be closer; but it is difficult to measure the stretch of a tensile specimen, and it is never done in ordinary tests.

Transverse Tests.—System used in the Metropolitan Water Works. The transverse test of a specimen is the cheapest and easiest test to make and is becoming very common. The only example known to the writer of the methodical application† of the transverse test on a large scale is the system carried on in the Metropolitan Water Works under the direction of our President, Mr. Dexter Brackett, M. Am. Soc. C. E. This system will now be

*See *Iron Age*, Vol. XLI, and elsewhere.

†By purchasers of castings.

described in some detail, and some conclusions stated which experience* with the system have suggested to the writer.

The specimen bars are 2 inches by 1 inch in section and 26 inches long, and are tested with a span of 24 inches, flatwise,—*i.e.*, in the weakest position. Specifications require bars so tested to stand 1900 pounds as a daily average from a cupola, with a deflection averaging at least 0.3 inch. Pipes are sometimes rejected altogether for weak iron, more often accepted at a reduced price for use at a lower pressure.

Method of Making Test Bars. The founders have been practically unrestricted in the matter of method of making the bars, the only stipulations being that the bars should be cast with a true specimen of the iron which went into the pipes; should be cast reasonably near to size, and should not be annealed. Consequently the bars have been cast by various methods. Some have been cast in dry sand with wooden flasks, some in dry sand with iron flasks and some in green sand (dry sand bars are cast on end, green sand bars flatwise); still others have been cast in dry sand and gated together in pairs. Most of the molds were faced so as to make a moderately smooth surface, but some bars have been cast in unfaced green sand and have had a rough sandpaper-like surface. One lot of bars was cast of extra large size and planed down to 2 inches by 1 inch, though these bars were not considered as test pieces.

Method of Obtaining Representative Iron in Bars. The bars were poured at such times and in such manner as would give fair samples of the iron, though the number of bars was of course limited. An actual instance will best explain: With a daily lading of fourteen 48-inch pipes there were cast four bars as follows: The first bar with the first pipe, the second bar with the fifth pipe, the third bar with the tenth pipe and the fourth bar with the fourteenth pipe; with twenty-seven 16-inch pipes there were cast three bars,—one with each of the first, fourth and seventh ladlefes, only about eight ladlefes being required to pour all the twenty-seven pipes; and bars for other work were poured at intervals according to the same idea, though never less than two bars were intended to be cast to represent any single heat.

The idea was to get the average quality of the iron for each day's cast from a given cupola, and if this average was unsatisfac-

*The writer owes it to the completeness of this record to state that this experience consisted of the testing of about 2000 bars. in a period of eight months, at two foundries, and daily observations of molding and casting many of the bars.

tory, the whole day's cast from that cupola was considered weak. It was not known what pipes were cast with each bar; moreover, not all pipes were cast with any bar; and, finally, the indications of a single bar were surely too uncertain to condemn castings by. This method, then, assumed that the iron from a given cupola ran fairly uniform during a day's heat; for, if some good and some bad iron was cast, there was no way of weeding out the castings made with the poor iron. Such an assumption would usually be fair, but it is not necessarily so. At one foundry, for example, a mixture containing 15 per cent. or more steel was cast from one cupola, for special work, at the beginning of the heat, while an hour later no evidence of steel was discernible in the iron. Moreover, large accidental variations in the charging of cupolas occur, especially when the charging is entrusted to ignorant negroes. On one occasion a marked difference each day in the character of the first test bar from a certain cupola led to the discovery that the charger was using no scrap for the first part against four-tenths scrap for the rest of the heat. It would take a large number of bars to justify in the least a rejection of iron cast in parts of a heat.

The details of the method of obtaining the iron for a bar are also worthy of attention. In any case a small hand-ladle is necessary for so small a casting. Three methods of getting the iron into the small ladle are available:

1. The iron may be poured from the large ladle into the hand-ladle. Foundrymen object to this method on the ground that the iron gets too cool by being poured through the air so many times; and also because there is considerable danger that the man who holds the small ladle may get burned by spilled iron. Either objection seems sufficient to condemn the method.

2. The iron may be dipped from the large ladle with the hand-ladle. This is a very good way, though rather hard on the hand-ladle.

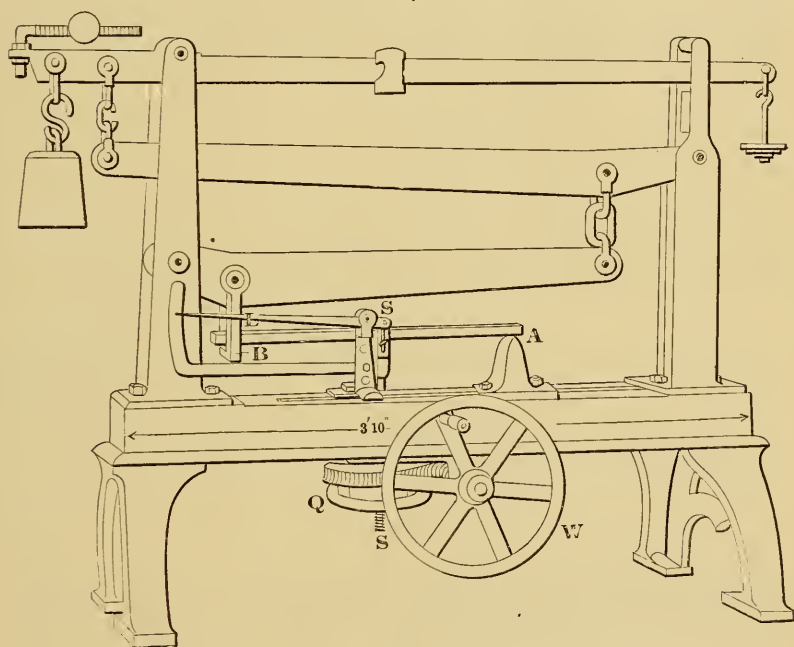
3. The iron may be caught by holding the hand-ladle under the cupola spout, over the large ladle. This was the method almost invariably used. A palpable objection to it arises when scrap or pig iron is added to the large ladle to cool the iron, thereby making its composition different from that of iron taken directly from the spout. As the cooling iron rarely exceeds 200 pounds in 8000 pounds, and is of approximately the same composition as the cupola iron, the difference is probably negligible. The method of pouring is generally considered by the founders to be important, bars poured with hot iron being usually considered strongest.*

*See paper by Thos. D. West, *American Machinist*, August 30, 1894, p. 11.

Method of Testing the Bars. The bars were tested as beams of 2 inches width, 1 inch depth and 24 inches span, supported at the ends and loaded at the middle. The load was applied gradually. The center deflection of the bars, at certain loads and at breaking, was recorded.

Testing Machines. The machines used for the tests were of the type made by Riehlé Bros., Philadelphia, for the purpose. An illustration is given in Fig. 4. The test bar rests at one end on a rigid support A, and at the other end in a rectangular loop, B, attached to a set of scale beams. The scales therefore receive only

FIG. 4.



one-half of the center load, but the scale beam is graduated to record the whole center load.

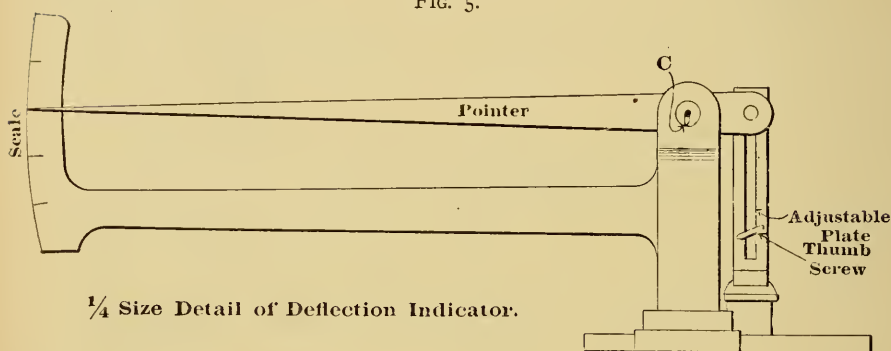
The load is applied by a screw, SS, which is spread at the top into a rectangular loop, through which the bar lies during testing. Power may be applied by the quick motion wheel, Q, which is fastened directly to the nut that works on SS, or by the slow motion wheel, W, which is geared to the nut by a worm. One turn of W causes a deflection in the bar of 0.0027 inch; 74 turns of W cause one turn of Q and a deflection of 0.20 inch in the bar.

The deflection is indicated by a multiplying lever, L, the

short arm of which is attached to the rectangular loop of the screw SS. Fig. 5 shows the details of the lever.

The common way of testing was as follows: A load of 10 pounds was first applied to the bar, then the deflection pointer was set at zero, then a load of about 1500 pounds was put on by quick motion, and finally the slow motion wheel was used up to the point of breaking. Deflections at loads of 1900, 2100 and 2300 pounds and at breaking were recorded, a short pause in applying the load being usually made to allow the deflections taken before breaking to be recorded. Some of the bars were tested by using the slow motion from 0 to breaking, making no stops when intermediate deflections were taken. As far as could be judged by comparison, the two methods give practically the same results, although the slow motion method has certain obvious theoretical advantages.

FIG. 5.



The total time of applying the load to a bar was about $1\frac{1}{2}$ to 2 minutes. It required only a little longer for the slow motion than for the quick motion method, because the latter involved a short pause at about 1500 pounds load for throwing the slow motion into gear, which partly offset the gain in time up to this point.

Precision of Testing. The weighed breaking loads are probably, in most cases, within 15 pounds of the *actual maximum load* which the bars sustained during testing. (This does not mean that different loads would not have been obtained if a different speed had been used.) The constantly varying load had to be kept balanced on the scales by moving the sliding weight along the scale beam, and adding necessary weights to the scale pan, and of course these operations were sure to entail some error. Another

error was caused by the sliding weight being moved by the shock at fracture. Occasionally a bar would break under 1500 or 1600 pounds, before weighing was begun, and its breaking load could only be estimated.

The deflections were liable to several more or less determinate errors:

(a) Any local compression of the bar at the knife edges caused a corresponding *positive* error in the deflection. This local compression was usually small, but was very noticeable with rough, sandy bars. In the case of rough bars the error could be largely eliminated by applying three or four hundred pounds before testing, in order to crush the sand at the bearing points.

(b) The compression of the scale bearings and the bending of the levers in the scale system caused an error which was observed in two cases to be about $+0.003$ inch.

(c) Any shifting of the deflection pointer in the circular bearing (c, Fig. 5) caused an error in the indicated deflection. This error was usually small, but probably reached 0.01 inch in some of the deflections taken after the bar had broken, as the shock of fracture shifted the pointer on its bearing. The error was as likely to be negative as positive. A slight alteration in the bearing, making the surface flat instead of circular, would remove nearly the whole of the error from this source.

(d) The whole backlash of the power screw and nut occurred as a positive error in final deflections observed *after* bars had broken. The backlash error could have been eliminated, and was eliminated in some cases, by watching the pointer and taking the deflection *at* breaking. Moreover, the correction to be applied to observations taken after breaking could be determined approximately by comparing the final deflection observed *at* breaking with the deflection observed after breaking. On one machine this backlash correction was about 0.005 inch and on another about 0.012 inch, the correction of course to be subtracted.

On the whole, the recorded deflections were probably rarely more than 0.01 inch in error, although warped bars and rough bars were liable to greater errors.

It is evident that the errors in testing are all negligible, considering the roughness of the whole test bar method. The errors are considered here in order that it may be seen that they *are* negligible.

It must be remembered, however, that, although the results of the tests give correctly enough the *actual* loads and deflections obtained by the method and speed of loading used, these results

are not strictly comparable with results obtained by other methods and with other speeds of loading.

Tables I and II give respectively the detailed and the collective summary of most of the transverse tests made for the Metropolitan Water Works from April, 1896, to February, 1897.

Discussion of the Metropolitan Water Works' Tests. The writer is confident that the iron at any of the pipe foundries would ordinarily have fulfilled the requirements of 1900 pounds load and 0.30 inch deflection in 2 x 1 x 24-inch bars. The effect of enforcing the requirements was to cause the founders to try to prevent even occasional lapses. Any iron meeting these requirements was accepted, but the founders came to take pleasure in producing bars of high strength, presumably without increasing the cost of the iron unnecessarily, sometimes by cheapening it. To the founder of the old school, at least, *good* iron means an open grade of iron, having low shrinkage and easily machined. Ordinary grades of such iron give weak test bars, however, and in one case, at least, it was found advisable to mix some scrap with the good iron to produce closer and stronger iron, thus making the iron cheaper. The foreman thought it most unwise for the engineers to choose strong, cheap iron in preference to good and more expensive iron. Moreover, the fear was expressed that the tendency to increase the strength (in the bars) and closeness of the iron was being carried too far.

The writer knows of one case where the requirements did cause some trouble to the founders. In a certain shop of one foundry were made all the green sand castings, including Metropolitan Water Works' small specials, and also a few large loam castings. The castings were mostly small and many of them required machining; hence it was desired to keep the iron soft. The attempt was apparently made to keep the iron just above 1900 pounds, but it too often went below; hence the iron for Metropolitan Water Works' specials was either brought in from some other shop, or the first part of the heat was charged specially for Metropolitan Water Works' castings.

There seems no reason to suppose that the requirements mentioned were too high, at least for castings about $\frac{1}{2}$ inch or more thick. For thinner pipes, since the more rapid cooling makes the iron closer, there is room for some difference of opinion.* The importance of specifying deflection, as well as strength, is shown

*The Howard Harrison Iron Co. specifies 1800 lbs. with 0.30 inch deflection for 12-inch and smaller pipes (the weakness presumably to be due to openness, not to cold shortness, etc.), and 2000—0.35 for 14-inch and larger.

by a test made by the writer of a bar of white "shot" iron. This bar stood 2000 pounds, and, on strength alone, would be considered good. The deflection, however, was only 0.21 inch. The white iron was about as different from ordinary pipe iron as iron can be from iron. But the question immediately arises whether 2000 or 2100 should not be required, or whether a maximum limit also should be made. Such questions require a more careful study of the subject.

Pipes from about $\frac{1}{2}$ to 1 inch in thickness seem of about the same texture as corresponding 2 x 1-inch bars; hence it would seem that the tests of the bars would show, as far as transverse tests indicate anything, approximately the character of the iron in such pipes. In this connection it is pertinent to consider what transverse tests do show. The question is too complicated for complete discussion here, but the following statements can be made with some assurance:

1. The transverse strength of a cast iron beam tends to increase (a) with the tensile* strength of the iron, (b) with the stretch limit of the outside layer.

2. The deflection of a cast iron beam increases with the stretch limit of the outside layer.

3. The ultimate strength of rectangular cast iron beams is roughly twice as much as would be obtained by the ordinary† theory expressing the relations between transverse strength of beams and tensile strength per unit section. This is largely due to the greater proportionate stretch as the iron approaches breaking; and the amount of the increase depends, as noted in (1) above, on the ability of the outside layer to stretch. The outside layer is seen to be very important in determining the behavior of a cast iron beam, and this is just the part that is most sensitive to small variations in the mold and to other conditions affecting cooling.‡

*That eminent authority, Mr. Thos. Turner, gives tables to show, however, that the *maximum* transverse strength and maximum tensile strength do not co-exist in the same iron. See "Metals," by A. K. Huntington and W. G. McMillan, Ed. 1897, p. 213.

†The ordinary formula for a beam supported at the ends and loaded at the middle is $W = \frac{2}{3} \frac{bd^2f}{l}$; where b = breadth, d = depth, l = length between supports, and f = tensile strength per square unit. Applied to the test bar, with iron of 20,000 lbs. per square inch tensile strength, which is fair: $W = \frac{2}{3} \frac{2 \times 1}{24} \cdot 20,000 = 1110$ lbs. The test bars stand about 2000.

The formula is more nearly correct below breaking.

‡For discussion of the behavior of cast iron in transverse test, see article by Prof. J. B. Johnson, Trans. Am. Soc. C. E., Vol. 22, 1890, pp.

These facts probably account for the erratic behavior* of test bars, and argue for great care in methods of making bars. The strength of pipes also must be affected by conditions of the mold or other circumstances affecting the cooling of the iron. Pipes turned out while still red, or pipes overheated in coating, may be injured. The planed bars of Foundry Y (see Table I, lines 16-19 and 44-49) were designed to avoid the imperfections of the outer skin. The iron in them was very noticeably coarser than that in the smaller 2 x 1-inch test bars cast from the same iron; and probably the iron in the planed bars was considerably lower in both tensile and compressive strength; but the planed bars stood, on the average, a little more load than the unplaned, and always deflected very much more. The larger transverse strength of the weaker iron was apparently due to the greater stretch of the outside layer, which allowed the inner iron to be brought into play to a greater extent.

Evidently the transverse test is a complex subject; but the pipes also have an outside skin and are much more often broken with the iron in transverse stress (by shock) than otherwise; hence it seems that the transverse test is a logical one, though perhaps impact tests would be more logical than are quiescent tests.

For pipes about $\frac{1}{2}$ to 1 inch in thickness, then, the transverse tests of 2 x 1 x 24-inch bars probably furnish us with at least a quasi-direct indication of the tensile as well as the transverse strength of the iron; and the conclusion might be drawn that it would be safe† and wise to choose for these pipes iron giving the highest strength (coupled with high deflection) consistent with capability of being cut and drilled.

Pipes less than about $\frac{1}{2}$ inch in thickness are probably of closer texture than the corresponding 2 x 1-inch bars. Hence the maximum strength of pipe would correspond to a test bar of a somewhat weaker and more open texture, and the maximum strength of bar might correspond to pipes of white brittle iron, especially with very thin pipes. Irons differ greatly, however, in the effect of size and casting on their texture.

Pipes more than about 1 inch in thickness are of a more open texture than the corresponding 2 x 1-inch bars. The writer has seen some pipes 1.4 inch in thickness that were of very much coarser texture than the corresponding bars; and, again, some that were only slightly more open; but never any that were closer than

98-109. "Applied Mechanics," Prof. G. Lanza, Ed. 1897, pp. 381-390. Article by Prof. J. Sondericker in *Technology Quarterly*, October, 1888.

*See conclusion 7, p. 241.

†See, however, p. 237 *et seq.*

corresponding 2 x 1-inch bars. Iron in these pipes is probably weaker than iron in bars, except when the texture of the bar is closer than that corresponding to maximum strength for the particular iron,—i.e., except when the bar is well toward white,* or chills at the corners.

Such is the theory that the writer came to accept as applicable to ordinary foundry irons. Subsequently the tables summarized in Tables I and II were compiled, in the hope, among others, of testing the theory.

About 0.7 per cent.† of the larger pipes and 6.3 per cent. of the smaller pipes shipped were found to have been split from the time of casting to that of laying. The results of bars cast on the days‡ with these split pipes were separated§ and studied individually and by average. Bars cast on days having burst pipes were studied similarly. Except in one case, the averages of these bars were not very different from the general averages of Table II, and the low individual results were no more common. In one case the bars cast with burst and split pipes were decidedly low;|| and the result, taken alone, looks significant.

Hence we may regard the averages of columns 2 and 3 in Table II as representing the quality of iron in split and burst pipes about as well as it does that in the other pipes, except in the case of Y_2 . There is nothing in the percentage of burst and split of "large pipes" which would indicate any marked superiority of pipes cast with stronger bars over pipes cast with weaker bars; or *vice versa*. The percentages of split pipes are small and differences can be properly attributed to accident, though foundry Z pipes not only show superiority in the table, but also are considered best by M. W. W. pipe yard men.

In "smaller pipes" Y_2 has only a few split and burst, and the corresponding bars were of low strength. The other foundries, however, though giving stronger test bars, have large numbers of pipes split in transit. The discrepancy is so large that one cannot help wondering if it is all accident; and it throws a slight, but unpleasant, uncertainty over our theorizing; for these smaller pipes

*Some of the strongest bars the writer ever tested (about 2800 lbs. and 0.40 inch deflection) were of mottled iron. A heavy cylinder (5 inches thick) of this metal was satisfactory, but a small flange pipe was considered too hard.

†In all 288 out of 11,450 shipped, or 2.5 per cent.

‡The bar, if any, cast with a particular pipe is rarely known. See pp. 229-30, *infra*.

§See Table I, lines 11, 12, 23, 24, 25, 29, 30, 34, 35, 38, 41, 52, 53.

||See Table I, line 24.

are of just about that thickness which the writer had selected as being best indicated by the test bars. The results may be explained by one or more of several hypotheses:

1. The most obvious hypothesis is that the number of split pipes is so largely a matter of chance roughness in handling that the results do not truly indicate the relative strength of the pipes. The only reason that can be urged for giving any weight to the number of split pipes, as an indication of the strength of the pipes, is the assumption that, with so large a number of pipes, the differences in handling would average up in the long run and the stronger pipes would come out ahead.* Moreover, one of the Met. W. W. pipe yard sub-foremen, who received most of the smaller pipes included in Table II, and assisted in cutting off the split portions of these pipes, states that "there was something wrong with the iron" of those broken pipes; that they were brittle and tended to crack off unevenly in cutting. The foundry Y pipes, on the other hand, were found of softer iron and cut smoothly.† These facts indicate that the high percentage of split pipes was really due to brittle iron, though the test bars were strong.

2. Our test of bars is by slowly-applied load; whereas, in practice, pipes are broken by sudden shock. Perhaps iron may be strong and elastic under slowly-applied load and still weak under shocks. If load only were observed, and not deflection, this hypothesis would not lack supporting evidence; but it does not seem probable that iron, having both load and deflection high, can be brittle even under shock. The enduring of stress is, however, connected with intermolecular movements about which we cannot reason confidently.

3. It may be that the test bar is not so good an index of iron in the corresponding castings as we would fain believe, even when its texture appears to be nearly like that of the casting. All who have studied the behavior of iron in transverse test, particularly, agree that it is complex. Moreover, differences, too small to be noticed by the eye, may be important in their bearing upon the internal condition of the iron.

*And the difference in strength of foundry Z and foundry Y pipes is seemingly not slight. If the quiescent load and deflection of the bars were an index of the ability of the pipes to bear shock, then the pipes would be able to absorb work proportionally to the products of the test bar loads and deflections: Z pipes : Y₂ pipes :: 2310 x .420 : 2030 x .352 :: 1.36 : 1 : that is, Z pipes would be about 1-3 stronger.

†The same foreman asserts, and from much experience, that among the larger pipes foundry Z pipes are clearly the toughest and most convenient for cutting, while foundry Q pipes are very hard to cut smoothly, as they tend to crack.

4. The most plausible hypothesis, however, seems to be that removing the pipes red hot from the molds renders them brittle. We have seen how important is the outer skin in determining the behavior of iron under stress. Columns 17 and 18 of Table II show the facts in regard to turning out the pipes. Unless a determined effort is made by consumers, pipes will continue to be turned out red hot, as the delay of allowing pipes to stay in until cool inconveniences the founder and diminishes his output. It may be that a more open grade of iron, of low strength in test bars, stands being turned out hot better than closer, stronger iron; but as the lower strength is liable to be due to other causes than openness, it would be futile to specify low strength.*

At the outset the writer thought that the transverse tests of a single size of specimen bar would be most safely treated as wholly indirect† tests, from which point of view one would not necessarily be surprised even if weaker bars (in quiescent test) accompanied stronger pipes in some cases. The contradictory nature of the results, however, and the evidence that irons of different natures could have the same test bar strength and deflection, enjoined the application of the theory.

The matter of chemical durability of pipes seems to be more amenable to reason and deserves our attention.

CONCLUSIONS ON TESTING.

1. Owing to differences in conditions of cooling, no test bar can be a true sample of the iron in its corresponding casting. The differences are further complicated by more or less marked variations in texture from center to surface in both test bar and casting.

2. Judging by the appearance of iron in corresponding pipes and test bars, the 2 x 1-inch bar gives a fairly good sample of iron in pipes of about $\frac{1}{2}$ to 1 inch in thickness. Iron in thinner pipes will be closer and usually stronger‡ (in gradually applied stress, at least) than iron in corresponding bars; and iron in thicker pipes will be more open and usually weaker† than iron in corresponding pipes.

3. The transverse test shows neither the tensile nor the compressive strength of the iron in a bar, but involves a complication

*See footnote, p. 234.

†See pp. 227-8.

‡Lines 9 and 10, 21 and 22, 32 and 33, of Table I, give comparisons between pieces, with *planed surfaces*, cut from pipes and bars with the *skin* on. The comparison still shows greater strength of test bars, but is not a fair comparison, as will be evident from p. 236.

of conditions that defy accurate determination. The following statements, however, appear to be true:

(a) Transverse strength usually increases with tensile strength of iron, and with stretch of the outside skin of iron.

(b) Deflection increases with the stretch of the outside skin of iron.

The nature of the outside skin* is seen to be a very important factor in the behavior of iron under transverse stress, as it is also in tensile stress.

4. Notwithstanding the complexity of the transverse test, it seems to be the best single test for general use, because deflection, as well as strength, can be readily measured. Moreover, it is particularly appropriate in pipe irons, because pipes usually break with the iron in transverse stress. However, as this stress is generally caused by shock, perhaps a good impact test would be more logical.

5. The writer accepts it as probable that the strength of pipes that have not been turned out of the molds red hot is measured in a rough comparative way by the strength and deflection of the 2 x 1-inch test bars. It is sure that exceptions to the rule will be found, as, for example, in the case of thin pipes (say $\frac{3}{8}$ inch and less) cast with some irons.†

These conclusions rest upon the general impressions of the writer gained from examining fractured sections of pipes and bars, the impressions of men who cut and handle the pipes and the general plausibility of the idea, in spite of recognized complexities. That iron of, say, 2300 pounds—0.40 inch test bar strength makes stronger pipes than iron of 2000—0.35 cannot apparently be proved with certainty, however, by use of the pipes. A large factor of safety against water pressure, and chance in the matter of breakage by handling, cover up the differences.

6. The large percentage of split pipes of the smaller diameters, from foundries having the stronger test bars, and the opinion of pipe yard men, gained from cutting off broken spigot ends, that these pipes were brittle, seem most reasonably explained by the fact of the pipes being turned out while still red hot.‡ Unless

*It would seem that making bars in a baked mold, as the pipes are made, would minimize the differences between bars and pipes due to difference in character of skin.

†See p. 236. According to the writer's observations, ordinary grades of iron become too hard for convenient cutting and drilling before they attain their maximum strength. Hence, with good inspection, there would be little danger of getting iron weak on account of being cast in too thin pipe.

‡See Table II.

these results can be attributed to this cause, or to chance, the fifth conclusion is untenable.

7. The precision of a single transverse test of 2 x 1 x 24-inch bar is very low. Flawless bars, cast from the same bath at the same time, under conditions as nearly similar as possible, varied on the average about 100 pounds in corrected load and 0.03 inch in corrected deflection. Moreover, much larger variations were common, the maximum variation in load being 440 pounds, and the maximum variation in deflection being 0.088 inch, and there were seven differences exceeding 200 pounds.* These erratic variations are as great as those between irons of widely different natures. It is pertinent to ask whether the pipes vary as much in strength as do the bars.

8. Notwithstanding the complexity of the transverse test and the low precision of results, the regular testing of 2 x 1-inch bars for transverse load and deflection enables the observer to detect the larger variations in charging the cupola during a heat and from day to day, as the writer can testify from experience. The careful examination of the texture of the fractured sections of the test bars aids greatly in judging the iron. Appearance usually corroborates results of tests.

9. The test bar does not in any degree supersede the function of the experienced inspector, though it should aid him in judging the iron. Not only is the inspector indispensable in discovering imperfections in castings, but his opinion of the iron, obtained from observation of its behavior under the hammer and from seeing rejected castings broken up, serves as a valuable check on tests which have not our perfect confidence. Moreover, the inspector must say whether the iron is suitable for cutting and drilling.

10. The following methods of making and testing bars are believed to be preferable:

(a) Use dry sand molds in iron flasks. A core spindle 4 to 6 inches in diameter will serve well.

(b) Use an iron pattern and pull it lengthwise, so as to have no seams or fins on the bars.

*These results obtained from eighty-five pairs of bars, forty-three pairs being green sand cast in separate flasks; and forty-two pairs being dry sand, the two bars of a pair being gated together and poured as one casting. A set of bars, cast to see whether green sand or dry sand bars are stronger, resulted as follows: Green sand bars exceeded in ten pairs by 155 pounds in load and 0.049 inch in deflection, on the average; dry sand bars exceeded in seven pairs by 111 pounds and 0.024 inch on the average.

(c) Dip the iron for the bars from the large ladle just previous to pouring the pipes or other castings.*

(d) Allow the bars to remain in the flask until cool.

(e) In testing, maintain a stated speed. Many of the Metropolitan Water Works' tests have been made at the rate of about 0.4 inch deflection in 2 minutes. If mechanical power were available, it would insure greater uniformity.

(f) If green sand bars are used, apply the load so that the "cope" side of the bar, which is almost invariably somewhat imperfect, shall be in compression.

(g) The writer would have at least two bars cast with every test ladleful of iron, in order that the degree of precision of the tests may be constantly known. And this, even though only two bars were allowed for the heat. In the latter case the inspector could guard against fixing one part of the heat by changing at will the time of pouring bars.

11. Planed bars are so entirely different from unplanned bars that no true comparison of irons can be had by comparing results of planed bars from one iron with those of unplanned bars from another iron. Bars cast $2\frac{1}{2}$ inches \times $1\frac{1}{2}$ inches, and planed on four sides to 2 inches \times 1 inch, deflect about 50 per cent. more than unplanned 2-inch \times 1-inch bars of the same iron.

12. Rumbling bars for about thirty minutes increased the strength from 8 to 12 per cent., and the deflection about 15 per cent. Hence, in judging iron, rumbled bars are not to be compared with bars not rumbled.

13. Bars containing considerable flaws, especially in the tension side, are of no use as tests of the strength of an iron, though they may show that flaws are due to the iron and would be liable to occur in the pipes.

14. Some of the uncertainty in the use of test bars would be eliminated by a practical application of Captain Henry James's idea of having bars of the same thickness as the castings (see p. 226). It would be well to modify the idea, and have bars of a thickness *equivalent in cooling* to that of the castings.

The following is a suggestion for such a method for pipe iron:

(a) For pipes 0.4 to 0.5 inch thick, use bars 2 \times 0.6 inch.

(b) " " 0.5 " 0.9 " " " 2 \times 1 "

(c) " " 0.9 " 1.4 " " " 3 \times 1.5 "

*It may be well to state that a mischievous foreman could often increase the strength of his test bars by stirring a few steel borings or turnings into the iron in the hand ladle.

All bars to be cast in dry sand, as are the pipes.

The reason for the excess of thickness of the bars is that iron in bars cools more rapidly than iron in pipes of the same thickness, for obvious reasons. The relative thickness of pipes and bars here given was based on impressions of appearance of fractured sections of pipes and bars, and a few careful comparisons. No study was made, however, with this particular purpose in view.

The proposed system is still palpably defective in that the test bar has four cooling surfaces, hence four planes of intersection of crystalline structure, four sides having the closer skin of iron, and four corners, which cool rapidly and chill when the iron has a tendency to chill. In a few instances the tension corners apparently (judging by snapping noises) break before the rest of the bar. In the other cases they must determine the deflection at which the bars break, thus limiting the results. A section of a pipe, on the other hand, has only two cooling surfaces. The difficulty might be avoided by planing, from each of the two sides of the bar, a layer equal in thickness to about half the thickness of the bar; the bars could be made wide enough to plane to 2 x 1 inches. A few bars of this kind, which would of course cost considerable machine work, would show more, in the writer's opinion, than many unplanned bars.

15. Finally, it should be remembered that the matter of chemical durability has been neglected in our tests, though it would probably be wise to pay attention to this side of the question of suitable iron.

(c) Chemical Analysis.

This also is an indirect test of the physical properties of iron, depending for its utility on the data that have been collected in regard to the physical behavior of irons of certain compositions. The chemical composition of a given iron is probably an exact characterization of that iron in so far as the composition can be accurately determined. There is no doubt that iron in a new casting is like that in an old casting, provided the chemical composition of the two irons is identical.* Hence chemical analysis bids fair to furnish a scientific method of duplicating satisfactory irons, thus making the results of experience available for present use. Of course the application of the chemical method is not nearly perfected, but it has been carried far beyond the published facts by a few of the larger works that have employed chemical and physical test for years. It would be possible, even with the present

*Contrast statements in regard to physical test on p. 228.

knowledge available on the subject, to specify certain compositions of iron that would give very satisfactory castings, and in time chemical specifications will probably be commonly made. At present, however, it would be expensive (in first cost at least) to carry out such specifications.

Chemical analysis might be used, under the present system, in cases of doubt to aid the engineer in deciding as to the suitability of certain castings.

Coatings for Cast Iron Water Pipes.

It is probable that nearly every engineer who has had a large number of pipes to lay has resolved that he will do something to dispel the mist that hangs about the subject of preservative coatings. Very many seem to have made concoctions of coal tar, asphalt, linseed oil and other things, in the endeavor to strike the fortuitous combination of cheap products which would adequately protect the metal. If all these experiments could be published the engineering world might finally arrive at a choice by rejection. As it is, the same ground is covered several times over with the same disappointing results. The question of preservative coatings belongs properly to the skilled chemist, but it has been attacked with some assurance by persons (including the writer) who are not chemists. The results of the writer's observation, study and experiment, made in connection with the Metropolitan Water Works, will be given.

COAL TAR COATING.

The details of the application of this coating have already been described.* Coal tar is a very complex mixture; indeed, the fact is so well known that people are not seldom heard calling a doubtful drug "one of those coal tar products." Moreover, coal tar varies very widely according to the coal used and the temperature maintained in the manufacture of the gas. Furthermore, crude tar varies at different heights in the tank in which it is collected at the gas works. But no tests are made to obtain any particular kind of tar for coatings. The unrefined overflow from the hydraulic main of the gas plants is purchased where it can be obtained easiest and cheapest. Specifications often call for deodorized tar, but the most noticeable thing about coating tar is its dense and pungent fumes when heated.

The degree of fluidity of the tar varies with the composition and with the temperature. In summer tar is usually more fluid than molasses; in winter it has often to be melted out of the barrels.

*See p. 222.

This crude tar cannot be used as a paint for cold surfaces, because it will not harden. And tar from the coating vat, though always somewhat refined by the continued heating, does not harden sufficiently when applied to cold surfaces. This suggests the philosophy of the whole tar process of coating. By the heat of the pipes the tar is distilled down to a compound which is solid at atmospheric temperatures. A very favorable condition for this volatilization of the liquefying constituents (which are also the most volatile constituents) evidently exists when the tar is exposed to the air, spread, as it is then, in a thin film over the hot pipes; and that rapid volatilization takes place at this time is indicated by the dense fumes given off.

As a corollary to the foregoing it follows that the temperature of the pipe, as it *emerges* from the tar bath, is one vital factor in the character of the coating. If the pipe is too hot, the coating is over-distilled and becomes too brittle, or may even be reduced to earthy, carbonaceous residuum. If the pipe is too cool, a thicker coating is formed, which will not harden sufficiently, will come off on the skids and will run in warm weather. Thin pipes must be heated hotter than thick pipes, because the thin metal does not hold the heat so long, and hence the distillation must be more rapid at first. The writer made an attempt to measure the temperature of some pipes just before they were dipped. An ordinary thermometer was of course of no use, nor could an electrical device be found which experts would recommend to record such low temperatures. Hence the writer procured several chemicals which are said to pass through noticeable changes at certain fixed temperatures: red iodide of mercury, which is said to change to the yellow at about 300 degrees F.; yellow stick sulphur, which fuses at about 235 degrees F., and silver nitrate, which fuses at 424 degrees F. Every pipe which was tried turned the red mercuric iodide to the yellow form, but no pipe, apparently, fused the silver nitrate. The effect on the latter and on the sulphur was hard to observe on account of the heat and smoke; hence the only conclusion that could safely be drawn was that pipes, just before coating, are usually considerably over 300 degrees F. With tar and thickness of pipe so variable, the proper temperature must be a matter of judgment on the part of dipman. A reliable and handy pyrometer would help, however, as it would enable the dipman to use the experience gained on one pipe in judging of the next one.

There is no question about the importance of having ovens properly arranged to heat the pipes uniformly. The brick fire arch, having bricks left out at intervals all along the position of the

pipe, is rather satisfactory. The single opening at one end of the pipe is decidedly unsatisfactory. The soot that is deposited on the pipes may do some harm. More elaborate and more nearly perfect schemes for heating pipes will quickly suggest themselves, but it seems probable that a careful application of the present methods will give results as satisfactory as a crude tar coating warrants. Careless application will vitiate any method. Thus, at one foundry the pipes are often wittingly under-heated on days when strong northerly winds prevail, because the wind makes it difficult to heat the ovens, and the day's work must be done just the same. Again, the pipes which stay in the oven during the dinner half-hour are liable to go into the tank too hot, because they are left in the oven too long and are not allowed to cool down. In general, the men fall into a certain routine of work,—so many pipes to brush out, so many to mop out, so many to roll into the oven, etc., between dippings,—and this routine fixes the time of heating. A good dipman will not allow very noticeable errors in temperature to pass, but he will not delay the routine for minor errors. In other words, the application of the method is inferior to the best judgment of the dipman.

The character of the tar in the bath is another important variable. New tar gives softer coatings, other things equal, because it contains more of the lighter constituents. Thick tar gives thicker coatings than thin tar. The temperature of the pipe should be varied to meet variations in the coating compound. Fresh tar requires a hotter pipe than does old tar. Regularity in adding new tar would give greater uniformity in coatings, but tar is often not in stock when it is needed, and the dipman does not care much, so long as the coating passes—and the inspectors do not usually pretend to know much about coatings or to judge them very harshly.

The temperature of the tar itself does not count for much when the pipes are heated before being dipped, as is universal now. In the old method of heating the pipes by allowing them to remain in the dip half an hour or so, the temperature of the dip was very important, though less so than it would have been with crude tar. The temperature of the tar in the present method is usually about 220 degrees to 230 degrees F. Observations of men at the foundry on temperature of the dip, and the writer's observations on small quantities of tar, indicate that new tar, on account of the lighter constituents,* does not at first rise above 220 degrees F.

*The law of fractional distillation is that a mixture, when distilled, remains at the boiling temperature of that constituent which boils at the

Later it rises to 350 degrees F., if heated sufficiently. It is evident that the old method of allowing the pipes to come to their proper temperature in the dip would lead into difficulty if the crude tar was fresh in the tank, as it would be difficult or impossible to raise the pipes to the required 300 or more degrees.

Small pipes are, as a rule, carelessly heated, and the writer has often seen very hot pipes lowered into the tank, where they caused a violent boiling and much yellow smoke (yellow smoke is the founder's sign of an excessively hot pipe). An inspector said that at one foundry pipes hot enough to set fire to the tar are so common that lids are rigged so that they can be rapidly unhooked and allowed to fall over the tank and smother the flames.

DEAD OIL.

Specifications often call for the use of dead oil of coal tar in the dip. Dead oil is defined as that part of coal tar which is obtained, in fractional distillation of coal tar, between the temperatures of 410 degrees and 750 degrees F. approximately. It contains both the creosote and the anthracene oils. Whether the commercial article agrees with this definition is unknown to the writer.

Some commercial dead oil that the writer tried evaporated about one-seventh as rapidly as water, both being exposed to the air. A brown cake was left in the bottom of the vessel. The misconception is probably often entertained that dead oil bears to tar coating a relation similar to that of linseed oil to paint. A better comparison would be that between dead oil in coal tar and turpentine in paint. Dead oil is of use principally to thin back the tar when it becomes thicker than the dipman likes it. Ordinarily the necessary adding of fresh tar is sufficient to keep the tar thin. At one foundry no dead oil would ever be used if the engineer did not occasionally require it. At another foundry it is the regular practice to use one barrel of dead oil to about seven of coal tar. A change was made at one foundry from no dead oil to about the above proportions, but it had no visible effect on the character of the coating. The effect on the composition of the tar dip was to increase the proportion of the heavy oils in the tar from about 25 to about 35 per cent., and perhaps the change really did improve the coating.

TAR AND LINSEED OIL.

The use of linseed oil in tar coatings dates back to the first

lowest temperature until that constituent is gone; then rises to the next lowest boiling point and remains there, and so on.

tar coating of Dr. Robert Angus Smith, a patent for which was taken out in Great Britain in 1848. The patent states that pipes were first to be cleaned and then preferably coated with linseed oil. Pipes might be heated before dipping or allowed to come to a heat in the mixture. The tar was distilled to "a thick, pitch-like mass," and kept at a temperature of about 300 degrees F. Pipes were left in the dip about thirty minutes. Dr. Smith found it "desirable to pour a quantity of linseed oil on the coated surfaces," which process had "the effect of removing any excess of tar, and the oil running into the tar kept it fluid and prevented its becoming unsuitable for further use." Such was the first coating of Dr. Smith. The writer found several different coatings described as Dr. Smith's, and it is probable that the doctor improved on his original one. The foundrymen to-day often call the crude tar coating in present use "the ordinary Angus Smith coating." In "Water Supply of Cities and Towns," by William Humber (published 1876) two methods used by Dr. Smith are given. In both, the dip contained gas tar, Burgundy pitch, oil and resin, the percentage of linseed oil in the second method being five or six. In the first of these methods the pipes were heated to from 400 degrees to 500 degrees F., and the dip was also kept hot. In the second, the dip only was heated, and the pipes were allowed to take the temperature (300 degrees F.) of the dip. It was supposed that the pores of the iron opened to receive the tar.

The questions that concern us now are whether linseed oil improves the quality of tar coating, and, if so, what method can be adopted for its use. On the first question we seem, as usual, to have no direct evidence. Old foundrymen will say that the present coating is not so good as the former coating was, but there are no comparative records available, so far as the writer knows. The writer has been unable to find out from records, or by questioning foundrymen, how much and in what ways linseed oil was used in the past, and when it ceased to be used. One very intelligent employe, who had been in the foundry business for about twenty years, thought there had been no linseed oil used at the foundries around Philadelphia since about 1872. Specifications throw little light on the subject, as they often contain directions that are not followed. It seems probable that the practice of using linseed was gradually dropped, perhaps on account of a change in the character of the tar obtained from the gas works, perhaps for other reasons of convenience; perhaps with the knowledge and consent of engineers, and perhaps without their knowledge. At any rate, the comfortable feeling of a question pretty well solved has con-

tinued; though perhaps, if the truth were known, the modern crude tar coating would be found to be living on the hard-earned reputation of the linseed oil coating. If records of the composition and behavior of coatings had been carefully kept and made available to students of the subject, many years of experience, now of little use, would have been saved to the world; and unless more care is taken, the next generation will make the same complaint.

In default of sufficient experience, we must resort to theory. The japan coating of Edward Smith & Co. is the result of careful theorization,* and the pamphlets issued by that firm, containing articles by Mr. A. H. Sabin, chemist for the firm, and by others give many facts in regard to preservative coatings. Mr. Sabin puts up a very strong plea for linseed oil, but he discards coal tar as a filler and accepts copals and also asphalt, which chemists usually consider as a more enduring compound than the complex and volatile coal tar. Mr. Sabin is also enabled to use a large percentage of linseed, and without any injurious dryer, because he bakes his coating. Now, whether or not the asphalt is better than tar, the arguments brought forth for the use of linseed seem pretty strong, and the writer would make use of them to give some evidence that linseed oil would improve coal tar coating.

Assuming, at any rate, that linseed oil would improve tar coating, the writer attempted to find out how it could be successfully applied to the present practice. At the McNeal Foundry an experiment had just been tried with an imported English tar and raw linseed, the fact that crude American tar could not be used with linseed having been proved at this foundry in previous years. The English tar was said to be somewhat refined, but appeared about the same as the American crude tar. The tar pit was cleaned out and English tar and raw linseed, in the proportions of ten tar to one linseed, were put in. The mixture became thick and lumpy, and all efforts to make a passably smooth coating failed. Even a temperature of 350† degrees F. failed to improve matters and pipes had to be recoated. No more linseed was added to the dip, but fresh tar and dead oil were added as needed, so that the proportions of linseed steadily grew less. Finally the tank was cleaned out and the use of crude American tar resumed.

The following is a description of some of the experiments tried by the writer with tar and linseed: The mixtures were made mostly in ten-quart porcelain-lined kettles. The specimens coated

*Also of much experience, though not with conditions such as exist in water pipes. †See note p. 250.

were fragments of pipes, the pieces being usually about 3 to 5 inches wide and 0.5 to 1.25 inches thick.

1. Twenty-eight parts of English tar and 1 part of raw linseed. The linseed, cold, was added to the tar at 240 degrees F. Violent frothing took place. The mixture soon doubled its volume and ran over. Coating out of the question for practical use on account of frothing and lumpiness.

2. Twenty-eight parts English tar plus 3 parts raw linseed that had been boiled for ten minutes. Ingredients mixed with tar cold and brought to liquid state at about 340* degrees F. Less frothing than before, but coating useless. Soft oil collected next the iron, and dull earthy tar outside. Dead oil helped matters somewhat, but coating remained useless.

3. Twenty-eight parts English tar plus 1 part commercial boiled linseed (guaranteed by an acquaintance as not having been boiled "through the bung-hole"). At 230 degrees F. violent frothing occurred; and, though a fairly good coating was obtained on a small scale, the method is out of the question for regular work. Dead oil did not help.

The foregoing experiments indicated that such crude tar could not be used.

4. In order to get tar at least somewhat refined, took 4 quarts of tar from the coating tank. Added $\frac{1}{4}$ quart of boiled linseed oil thereto. Frothing was too vigorous for any thought of practical application.

5. Boiled some crude tar for about $5\frac{1}{2}$ hours. At the start, the tar was a thin fluid at atmospheric temperature. After boiling, the tar was a soft solid at atmospheric temperature. During boiling, the temperature of the tar remained at about 220 degrees F. for about an hour, then rose to about 290 degrees and stayed there for a time, and finally became about 350 degrees.

To 16 parts of this boiled tar added 1 part of boiled linseed. No frothing occurred, even at 400 degrees F. The mixture was thick and did not harden sufficiently on fragments of $\frac{1}{2}$ -inch pipes. Later it occurred to the writer to try thick pipes (an inch or more thick), and there was no difficulty in getting the coating even too hard. No frothing occurred when dead oil was added to thin the mixture.

The experiment showed that linseed oil could be used with partially refined tar, but it also indicated that the application of the method required more intelligent care than does the crude tar method.

*This temperature seems abnormally high in view of the other results.

Since making these experiments, the writer has found an old specification for tar coating, the method of which agrees so closely with the results of these experiments that the following quotation is made:* "The varnish, or pitch, is to be made from coal tar, distilled until all the naphtha is removed, the material deodorized and the pitch reduced to about the consistency of wax or very thick molasses. At least 8 per cent. of heavy linseed oil must be added." It is rather humiliating to come back to the results of thirty years ago. It would not be so if the old method had been deliberately abandoned for a better one; but, as already intimated, it is not apparent that such was the case.

Refined tar is now out of the market, though a tar residuum or pitch is used in roofing and for walks. As the above experiment indicates, it would be an easy matter to make some refined tar.

Procured some of the roofing pitch mentioned above. It is a solid, just viscous enough to slowly find its level in warm weather, but hard and brittle in cold weather.

6. Roofing pitch alone. Coating was thick and very glossy, but of course rather brittle. Such a coating might give excellent results if handled only in warm weather, but would probably fly off in cold. This coating has stood water tests for about a couple of years without losing its smoothness and lustre.

7. Nine parts roofing pitch and one of boiled linseed. A thick, glossy coating, not so brittle as pitch alone.

8. Nine parts pitch to 2 boiled linseed. Better than 7 as regards brittleness.

9. Nine parts pitch to 3 boiled linseed. Coating more bulky and less smooth than the others.

A greater proportion of the linseed would make the coating like paint, and drying would be too slow, unless baking were resorted to, as in the Sabin japan.

ASPHALT COATINGS.

It is truly charged against coal tar that it continues to decompose, so that finally nothing but a friable, earthy pitch is left. It is said to be characteristic of pyrogenic (fire-formed) compounds, to which class coal tar belongs, that they are unstable at ordinary temperatures. Asphalt also decomposes with exposure, as demonstrated at the natural asphalt lakes, but nevertheless is thought to be more durable than coal tar. The only direct long-time comparisons that occur to the writer are in the matter of walks and pavements, and here there is no doubt that the asphalt has demon-

*See Report of the Cochituate Water Board, 1867-68, p. 17.

strated its superior durability. However, the conditions in a water pipe are different from those of a street surface; moreover, a coating material might be very durable in *itself*, and yet not form an *impervious* coating, as is the case with pure linseed oil used alone. Asphalt has not the aggressive penetration of coal tar, nor does it stick to things and cover everything so persistently as tar. A little drop of tar will smirch skin, clothes, paper and everything that comes near it without apparent diminution in size, while asphalt can be handled with impunity.

The usefulness of asphalt as a pipe-coating compound for cast iron has never been demonstrated, though asphalt has been and is still used largely in coating steel pipes. Some information on its success for steel pipes should be available by this time, but little has been published.

The writer tried many experiments with Alcatraz, or California asphalt. Grades of several degrees of hardness are made, and by mixing grades it is comparatively easy to get a good consistency. A temperature of about 260 degrees F. was needed. The coating is not brittle, not very smooth, rather dull and not very tenacious. In fact, the impressions of the coating were rather of a negative nature. There were no glaring defects in the coating, neither was it very attractive.

Linseed mixes well with asphalt, but the coating does not harden unless a hard grade of asphalt is used.

P. & B. PIPE DIP.

This is a patent dip manufactured by the Standard Paint Company. Its principal ingredients probably are asphalt and candle tar pitch. The latter is a pitch obtained by distillation of animal fats. This coating has been used somewhat on steel pipes, but not long enough for a test of durability. As applied to cast iron it gives a coating very similar to asphalt coating,—*i.e.*, not hard, not brittle, not very glossy, not very tenacious.

MINERAL RUBBER DIP.

This is a dip manufactured by the Assyrian Asphalt Company. The process is not patented, but is secret. The appearance indicates that the compound is largely asphalt, and the coating is somewhat similar to asphalt coating, only duller in appearance. The dip requires a temperature of about 400 degrees F. This dip has recently become very popular for steel pipes.

VARNISHES.

There are many cheap varnishes made from tar, and there are also more expensive ones containing asphalt and other ingre-

dients. These varnishes consist of some solid dissolved in a volatile carrier, which quickly evaporates, leaving the solid on the coated body. The engineers of the Metropolitan Water Works have used a number of these varnishes in painting over the coal tar coating, with the idea of filling up the pores in the coating. The writer has experimented with some of these varnishes.

1. P. & B. Universal Paint, manufactured by the Standard Paint Co. This is to many a very familiar varnish, because it is not forgotten after having been once used. The solvent contains carbon disulphide, the odor of which is sickening to most persons. The coating seems fairly good after it is on, but the odor interferes with its use.

2. P. & B. Ruberine, also manufactured by the Standard Paint Co. This varnish consists of "ruberoid" dissolved in naphtha. Ruberoid consists of California asphalt and candle tar pitch digested and vulcanized with sulphur. Ruberine dries rapidly and is hard to spread smoothly. It gives, however, a substantial, rubbery coating.

3. Tar varnishes. Two of these were tried, one an American and the other a Dutch product, imported by Paul A. Davis, of Philadelphia, and said to be much used abroad. The varnishes were thin, had the coal tar penetration, and gave smooth, good-looking coatings.

It is evident that the use of varnishes would be very limited, unless it were found possible to use them as dips; their rapid evaporation seems to preclude their use in this way; but trial alone, and on a large scale, would settle this question.

TESTS OF COATINGS.

Of course the only satisfactory test of coatings is actual use under known conditions. Small-scale experiments are often misleading and always inconclusive. Moreover, all coatings are so durable that it takes a number of years to form an idea of their relative value, and by that time something new is often favored on theoretical evidence. However, the small specimens used in the experiments above described were subjected to several tests.

1. Test for brittleness. Most of the specimens were tested by hammering to see whether the coating was liable to fly off in handling of pipes. Allusion to brittleness has been made in describing the coatings.

2. Test of porosity. It is known that tubercles start at minute holes in coating. It was thought that if acid did not injure the coating material itself, it would give a test of the porosity of

coatings by attacking the metal through the pores. Specimens of coated iron were put in glass jars containing a mixture of one part muriatic acid and two parts water. At the same time samples of the coating materials alone were put into other glass jars with acid of the same strength. Great activity was immediately apparent in the case of the coated iron, and a disagreeable gas with a sweetish odor was evolved. The coating materials alone, on the other hand, were apparently not acted upon. Their appearance, and the appearance of the acid in which they were submerged, remained the same to the end of the test, which was almost as long as the test of the coated iron.

The coatings were all badly undermined, and all but a specimen of Sabin's japan peeled off in many places. The iron was dissolved to the depth of $\frac{1}{8}$ inch in places, especially at the corners. The following is the estimate that was placed upon the specimens, beginning with the least injured:

TABLE A.

Coating.	Time Exposed.	Remarks.
1. Sabin japan.....	55 days.	{ Specimen said to have been rusty before being coated.
2. Crude tar.....	55 "	
3. { Tar and linseed.....	60 "	{ No distinction possible.
	Alcatraz asphalt, pitch and linseed....	60 "
	Mineral dip (Assyrian Asphalt Co.)..	55 "
	P. & B. dip (Standard Paint Co.)....	55 "
4. Alcatraz asphalt.....	55 "	Totally destroyed.
5. All the varnishes.....	55 "	

There was *only one* specimen of each coating.

3. Running water test. The following specimens have been kept in running Boston water. Many tubercles have already formed on corners and on the rough fractured edges, but only a few* on the smooth large faces that formed parts of the inside and outside, respectively, of the pipes from which the specimens of iron were broken. The writer's estimate of the coatings is as follows:

TABLE B.

Coating.	Time Exposed.	Remarks.
1. Tar and linseed..	2 years.	{ The coating is smooth and in good condition, except for a group of five $\frac{1}{4}$ -inch tubercles.
2. Mineral dip.....	2 "	
P. & B. dip.....	2 "	{ Few tubercles on large surfaces, but coatings rather earthy.
3. Alcatraz asphalt..	2 "	
		Badly tubercled and covered with crumbling blisters.

*This does not include the numerous tubercles, due perhaps to galvanic action, that were formed at many places along the copper wire wound around the specimens to suspend them by.

There was only one specimen of each coating.

The following samples have endured four months in running Delaware River water,—whereby they were scarcely tubercled at all, but received a heavy coat of mud,—washings to remove the mud, and finally seventeen months in running Boston water, where they still are. The specimens have only three to five incipient tubercles* and a few specks on the large surfaces, though there are a good many well-developed tubercles, as usual, on the rough edges of fracture and around the copper suspension wire. In general appearance the writer would rank them as follows:

TABLE C.

Coating.	Remarks.
1. Pitch,	Coating still glossy.
2. Pitch and linseed,	Coating still glossy.
3. Pitch and linseed, painted over with Dutch varnish.	
4. { Mineral dip, P. & B. dip.	Tubercles not more numerous than in the case of the foregoing specimens, but the surfaces rather earthy in appearance and not smooth.
5. Dutch varnish,	
	Freer from tubercles than any of the other specimens, but the surface is earthy and friable, black powder being easily scraped off.

There was only one specimen of each coating.

The following specimens endured the same treatment in Delaware water and subsequent washing off of mud, and were finally placed in a tank of water that is not often changed, where they have been about fifteen months. The tank has been used for much of the time for cement briquettes, and the water is hence very alkaline:

TABLE D.

Coating.	Remarks.
1. Pitch,	In good condition; few tubercles.
2. Tar covered with Dutch varnish,	" " " " "
3. Tar and linseed.	" " " " "
4. { Alcatraz asphalt, pitch and linseed, Tar,	" " " " "
5. { Mineral dip, Alcatraz asphalt and linseed (2 specimens), Alcatraz asphalt, pitch and linseed (another specimen), P. & B. paint (2 specimens), Dutch varnish.	
	In fair condition.
	" " "
	" " "
	Few tubercles, but coatings are rather earthy, and black will rub off.
6. { Mineral dip (another specimen) P. & B. dip, Alcatraz (2 specimens),	In bad condition; many well-developed tubercles; also crumbling blisters.

*A piece of pottery coated with Dutch varnish was not tubercled at all. This corresponds with the generally accepted idea that iron is essential to the formation of tubercles.

There was only one specimen of each coating except in the cases specially noted above.

The following table gives a *very rough* idea of the relative cost of the various coating materials. The crude tar results are based on actual records and are believed to be reasonably close. The other results are mere estimates, based, in the case of the dips, on the results for tar; in the case of the varnishes on estimated covering capacity; and in the case of the Sabin japan on results for steel pipes.

TABLE E.

Coating.	Approximate Amount required to coat one 48-inch pipe.	Approximate price.	Cost of Material for one 48-inch pipe.
Crude tar	3¾ gallons.*	\$3 per bbl. of 52 gallons.....	\$0.22
Pitch.....	5 "	\$5 per bbl. of 52 gallons.....	0.50
Pitch and linseed.....	.....	.....	0.70
P. & B. dip.....	20 pounds.	\$45 per ton.....	0.45
Mineral dip.....	20 "	\$75 " "	0.75
P. & B. Univers. Paint..	1½ gallons.	\$1.00 per gallon.....	1.50†
P. & B. Ruberine.....	1½ "	\$1.00 " "	1.50†
Tar varnish.....	1½ "	\$0.10 " "	0.15‡
Dutch varnish.....	1½ "	\$0.25 " "	0.40‡
Sabin japan.....	1½ "	\$1.75 " "	2.60‡

CONCLUSIONS.

Should the Sabin japan prove by use to be as good as it appears to be, engineers would have to decide whether it were economical to add from 5 to 10 per cent. to the cost of pipes in order to prevent in part a deterioration, in the carrying capacity, which has been found as large as 20 per cent. in 16 years in even large pipes.§ But the efficacy of the coating must be proved by several years of use.

As for the above tests, the tar compounds seem to have the best of them on the whole (barring the Sabin japan, which was tested only by acid), though the tests are *too few* and *too short* to serve as a basis for decided opinions. The writer would like to try roofing pitch on some pipes. He has considerable faith in the efficacy of thick, smooth coatings, such as it makes. The experiments show that only a thick coating will protect rough surfaces and corners. If the pitch proved too brittle to stand the handling

*About 30 per cent. of this lost by evaporation.

†Estimated cost of the coating applied as by a brush. Wastage might be excessive as dip, but the latter would be the only practical way for use on a large scale; hence the figures above are not strictly to the point.

‡This coating requires a comparatively expensive plant and considerable skilled labor, which would largely increase the total cost.

§See paper by Desmond FitzGerald, Mem. Am. Soc. C. E., Trans. of Am. Soc. C. E., Vol. XXXV, 1896, p. 241.

of shipping and carting, it would not be impossible to have a portable coating outfit. The writer would also like to see a refined tar and linseed oil coating tried on the commercial scale. He would suggest that it would not be a very expensive experiment for a large city to try the several coatings on some line of its pipes and thus determine in a rational way what coating was best for its water.

Rusty pipes will apparently not hold a coating. At one foundry were several 30-inch pipes having only little blotches of tar coating left on them. The writer was told that these pipes were coated only two years before, but were very rusty when coated.

The foundry scale* which forms the surface of castings will protect the castings from rust for some time. Even when a casting is allowed to stand in a shower or two, only streaks of rust on top are formed at first. All chipped surfaces, however, quickly rust, and it is noticeable that coating over chipped surfaces is often quickly destroyed. Whether this is due to the surface being rusty before coating, or to a poor adhesion of the coating to even clean chipped surfaces, is unknown to the writer.

The writer wishes to acknowledge his indebtedness to Mr. Dexter Brackett, M. Am. Soc. C. E., who suggested the paper and gave advice and friendly criticism; to Mr. C. L. Prince, superintendent of foundries of the Camden Iron Works, who kindly loaned lantern slides and negatives; and to friends in the employ of the Metropolitan Water Board for information and advice.

*Silicate of protoxide of iron. See "Metallic Structures: Corrosion and Fouling and their Prevention." John Newman, pp. 124, 125.

TABLE I. GENERAL SUMMARY OF TEST BAR TABLES WITH DATA ON CORRESPONDING PIPES.—SHEET A.

Note: This table contains results of most of test bars and pipes cast for the M. W. W., at four large foundries, between April, 1836, and February, 1897. For condensed summary, see Table II.

Data in Regard to Corresponding Pipes.																												
CORRECTED BREAKING LOADS AND DEFLECTIONS.																												
Below are given Average Loads and Average Deflections, Maximum and Minimum Loads with their Corresponding Deflections and Maximum and Minimum Deflections with Corresponding Loads.																												
No. of Line.	Foundry.	Description of Bars, etc.					Reference to No. of Table.	Time embraced by	No. of Bars in Table.	Col. 6 expressed as % total Bars.	Without Bars.														With Bars.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25				
1	X B	Dry sand—Two bars (Part 1 st)	132	9.52 days ¹⁰	62	15	2146	340	2775	384	1810	307	406	2588	273	1870	48 th A	1.15	725	17	7	.8	1					
2	"	in one flask	48	"	21	2076	322	2610	412	1725	322	414	2130	270	1870	48 th A	1.15	320	31	14	.9	0						
3	"	Dry sand—Two bars	49	"	52	2080	347	2880	366	1790	302	448	2070	280	1850	48 th A	1.15	275	17	4	0	1						
4	"	in one flask	21	"	22	2089	345	2495	340	1790	294	387	2005	275	1860	48 th A	1.40	435	7	2	.7	0						
5	"	Dry sand—One bar in	121	11.55	58	12	2081	339	2475	386	1730	279	398	2100	271	1900	48 th C	1.40	715	8	4	0	0					
6	"	a flask	62	"	30	2081	336	2400	372	1730	300	427	2165	283	1950	48 th C	1.15	290	4	4	.7	0						
7	"	Green sand—One bar	193	12.68	69	13	2254	362	2685	404	1785	397	462	2075	284	2020	48 th B	1.25										
8	"	in a flask.....	52	"	18	2231	354	2655	373	1880	347	405	2615	297	1870	48 th B												
9	"	Bars cut from pipe.....	2	"	2	100	0	2055	5 ⁺	2060	2050																	
10	"	Corresponding regular bars.....	1	"	12	86	14	2071	337	2440	343	1825	288	385	2170	288	1825	48 th A										
11	"	Cast with ladings containing (	27	"	12	67	33	2260	337	2655	406	2025	329	406	2655	399	2295	48 th A									
12	"	burst and split pipes ⁸	27	14	53	78	22	2094	338	2655	399	1400	17	410	2055	17	1400 [±]	48 th C										
13	Y 2	Rough green sand — tested drag up.....	2254	"	83	53	47	1057	314	2770	278	1760	296	370	1935	278	1830	26 th C	70	80	4	15	1	0				
14	V 1&2	Rough green sand (Rumbled)	121	"	100	0	2225	424	2460	442	1930	351	479	2350	327	2035	26 th D	85	60	7	2	0	0					
15	V 1	tested cope up.....	86	560	100	395	1720	206	490	2255	286	1720	206	490	2255	286	1720	36 th B	87	340	8	4	.3	1				
16	V 2	Green sand Corresponding 2 1/2" x 1 1/2" and planned to 2 1/2" x 1 1/2".....	43	"	100	0	2048	599	2235	540	1755	490	555	2070	460	2000	36 th C	1.03	75	15	6	0	0					
17	"	Cast 2 1/2" x 1 1/2" and planned to 2 1/2" x 1 1/2".....	154	"	4	100	2025	345	2250	348	1800	301	398	2160	287	1845	48 th B	1.13	90	20	4	0	0					
18	"	Corresponding 2 1/2" x 1 1/2" bars up.....	3	"	100	0	2048	419	2135	439	1895	397	440	2115	379	1895	48 th C	1.25	90	4	4	.5	0					
19	"	Corresponding 2 1/2" x 1 1/2" bars up.....	25	"	3	100	2054	349	2170	379	1870	300	395	2340	300	1870	26 th C	1.40	360	2	3	1	0					
20	"	Dry sand—iron flask	46	"	96	4	2056	376	2330	404	1770	291	450	2080	291	1770	26 th C	70	50	0	18	4	0					
21	"	Bars cut from pipe.....	2	"	100	0	1900	5 ⁺	1980	6 ⁺	1820	4 ⁺					26 th C	87	40	3	5	0	1					
22	"	Corresponding regular bars	1	"	1	100	0	2069	343		Only	one bar					36 th C	1.13	85	19	12	3	2					
23	"	Ordinary rough green sand	29	10	22	71	20	1950	332	2155	401	1700 [±]	322	401	2155	276	1970	36 th C	1.25	105	2	3	0	0				
24	"	cast with ladings containing (	29	"	10	100	0	1857	310	2010	315	1700	322	327	1835	284	1700 [±]	48 th B&C	1.40	970	1	7	.3	0			
25	"	burst and split pipes ⁸	29	5	11	61	39	1972	328	2120	371	1835	283	394	2100	283	1835	36 th C										

Observed Load.

¹Bars are 24" span; and approx. 2" wide x 1" deep—Results corrected for variations from 2" x 1", as follows—Cor. Load = $\frac{1}{2}$ measured width x (meas. thickness).² Corrected Deflection = Observed Deflection x measured thickness. ³Deflected for all causes but test bars. ⁴Split = split in handling or in transit from time of casting until laid, at some time usually unknown. (See foot note 3, table II.) ⁵% split is computed on number shipped, not on number cast. ⁶Burst = burst in proving press. ⁷Cast before test bars were made a cause for rejecting pipes. ⁸Parts 1 include bars that showed practically flawless fracture; Parts 2 include bars showing some small flaws in fracture. ⁹Rumbled for about 30 minutes in a chiller mill. ¹⁰Bars with split pipes are of course included in the general averages. ¹¹Working days.

TABLE I.—SHEET B.

No of Line.		Foundry.	Description of Bars, etc.		Reference to No. of Table.	Time embraced by Table.	No. of Bars in Table.	Col. 6 expressed as % of total Bars.	CORRECTED BREAKING LOADS AND DEFLECTIONS. Below are given Average Loads and Average Deflections, Maximum and Minimum Loads with their Corresponding Deflections and Maximum and Minimum Deflections with Corresponding Loads.												Data in Regard to Corresponding Pipes.								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Cor. Def.	Max. Load.	Min. Load.	Min. Def.	Cor. Def.	Thick- ness.	Cast.	Re- fect.	% Cut.	% Split.	Numbr.	
26	Z	A	Green sand.....	148 d'ys ⁶	563	95	5	2318	422	2836	465	1715	313	495	2420	313	1715					36" D	20	21	22	23	24	25	
27	Z	A	" " { Rumbled?.....	6 " 17 "	34	100		0	2567	470	2755	595	2110	345	535	2600	345	2110					48" B	20	21	22	23	24	25
28	E	"	" " { not Rumbled.....	6 " 17 "	30	88		12	2284	406	2605	468	1935	359	479	2540	359	1935					48" C	20	21	22	23	24	25
29	Z	A	Cast with ladings containing {	30 3 "	10	83		17	2452	423	2605	421	2270	428	460	2485	383	2560					48" B	20	21	22	23	24	25
30	Z	A	" " { burst and split pipes ⁸	30 8 "	31	97		3	2270	424	2420	465	2080	356	480	2410	356	2080					36" D	20	21	22	23	24	25
31	Q		Dry sand.....	203 "	665	82		18	2063	366	2550	33	1803	366	465	2086	270	2250					36" B	20	21	22	23	24	25
32	"		Bars cut from pipe.....	1 "	2	100		0	1996	478	2015	52	1975	435								42" C	20	21	22	23	24	25	
33	"		Corresponding cast bars.....	1 "	2	50		50	2120	355	2140	36	2100	35								48" B	20	21	22	23	24	25	
34	"		Cast with ladings containing {	31 4 "	15	94		6	2060	377	2130	33	1970	406	436	2060	31	2080					48" B	20	21	22	23	24	25
35	"		burst and split pipes ⁸	31 16 "	53	83		17	2040	365	2280	34	1855	33	43	2020	30	2135					42" B	20	21	22	23	24	25
36	X	N	Green sand—One { Part 1 ⁹	13 56 d'ys ⁶	105	77		7	2103	360	2515	424	1780	310	540	2045	285	1800					16" D	20	21	22	23	24	25
37	"	"	" bar in a flask.....	" 2 "	22	16		418	1765	310	472	2080	284	1855								16" E	20	21	22	23	24	25	
38	"	"	" Cast on d'ys having no sp't pip'g ¹⁰	28 12 "	34	100		0	2120	347	2445	384	1780	310	410	2170	285	1800					12" B	20	21	22	23	24	25
39	X	S	Green sand—One { Part 1 ⁹	14 27 "	53	70		16	2270	350	2745	363	1710	275	420	2465	275	1710					12" D	20	21	22	23	24	25
40	"	"	" bar in a flask....	" 2 "	11	14		11	2290	335	2605	354	1795	294	367	2430	294	1795					16" B	20	21	22	23	24	25
41	"	"	" Cast on d'ys having no sp't pip'g ¹⁰	28 5 "	15	83		17	2276	355	2525	337	1990	312	394	2235	304	2115					6" E	20	21	22	23	24	25
42	Y	2	For bars corresponding to 20" and 24" pipes see Sheet A., lines 13 to 25.																			8" E	20	21	22	23	24	25	
43	Y	3	Green sand—one bar in a flask.	24 4 days	5	100		0	2111	352	2270	412	1935	297	412	2270	297	1935					6" E	20	21	22	23	24	25
44	"	"	" " { 2 1/2" x 1 1/2" planed to 2 1/2" x 1 1/2"	42 "	42	100		0	2000	511	2230	553	1840	450	580	2095	450	2000					8" E	20	21	22	23	24	25
45	"	"	" " { 2 1/2" x 1 1/2" planed to 2 1/2" x 1 1/2"	15 "	15	100		0	1921	420	2130	450	1730	420	490	2105	350	1750					8" E	20	21	22	23	24	25

All from same cupola, which was used for small pipe work.

Notes 1 to 9, see Sheet A. 10 15% more rejected for deficient test bars. 11 Days having no split pipes were the exception in these cases.

All from same cupola, which was used for small pipe work.

TABLE II. SUMMARY OF TEST BAR TABLES AND OF PIPE DATA—CONDENSED LARGELY FROM TABLE I.

Note: This table contains results of most of test bars and pipes cast for the M. W. W. at four large foundries, between April, 1866, and February, 1867. The pipes and bars are the same ones to be found in more detail in Table I.

Data on Corresponding Pipes.																		
Test bars.																		
Foundry.	No. in Aver.	Aver. of Cor-rected Loads, lbs.	3	4	Size and Class of Pipes.	Range of Thick-ness, inch.	No. of Pipes Cast.	No. Re-jected.	No. Re-jected in Cut.	No. Ship-ped.	No. Split.	No. % Burst in Prov-ing.	Condition of Pipes when Flasks were Removed.				Time left in Flask. (Approximate.)	
													11	12	13	14		15	16	17	18
LARGE PIPES.																		
X B	678	2150	.246		48" A, B & C	1.15 to 1.40	2760	365	13.2	155	5.6	2395	15	0.6	2	.08	Cool. Mostly black hot— A few cool. 48" and 36" black hot; 830" mostly red hot. Mostly black hot.	Overnight. About 3 hours— A few overnight. About 3 hours; About 2 hours; About 3 hours— A few overnight.
Y 2	203	2030	.349		48" B & C, 36" B & C,	1.03 " 1.40	1875	75	4.0	100	5.3	1800	11	0.6	2	.11		
Z	861	2310	.420		48" B & C, 36" D	1.10 " 1.40	2215	90	4.1	55	2.5	2125	10	0.5	2	.09		
Q	665	2065	.366		36" D & B, 48" A & B, 42" B & C, 36" B	1.03 " 1.25	1835	395	21.5	65	3.5	1440	18	1.3	4	.22		
SMALLER PIPES.																		
X N	127	2085	.567		16" D & E	.75 to .81	1275	8170	13.3	0	0	975	97	10.0	0	.0	About 1 to 1½ hours.	
X S	64	2280	.353		12" B & D, 16" B	.57 " .65	555	9165	29.8	0	0	380	29	7.7	2	.5	About 1 hour.	
Y 2	203	2030	.349		20" C & D, 24" C	.79 " .87	570	30	5.3	40	7.0	540	5	0.9	2	.4	About 1 to 1½ hours.	
Z	473	2285	.418		16" D, 20" D & E	.75 " .92	1895	95	5.0	10	0.5	1800	103	5.7	0	.0	" " " "	

Results corrected for variations from 2" x 1", as follows: Cor. Load = $\frac{1}{2}$ measured width x sq. of thickness. Bars are 24" span and approximately 2" wide by 1" deep. Corrected Deflection = Observed Deflection x measured thickness. Rejected for all causes but test bars. Split from time of casting until laid—Nearly all these pipes are now in the ground. The majority of split pipes were found split at end of the journey from foundry to pipe yard. About 15 of the large and about 30 of the smaller pipes were split in teaming from pipe yard to place of laying. The numbers of split pipes above given are probably somewhat too small, as the formal records of split pipes are somewhat incomplete. $\frac{1}{2}$ split and $\frac{1}{2}$ burst are figured not on number cast but on number shipped, which is more nearly correct for the purpose. $\frac{1}{2}$ Nearly one-half of these rejected for wrong dimensions. Also 13 " not included above, rejected for deficient test bars. $\frac{1}{2}$ About one-half of these rejected for wrong dimensions; also 13 not included above were rejected for weak test bars. Moreover, included in the 165 are 3 ladings of 13 pipes each, rejected for "hard, brittle iron"—test bars with one of these ladings were 1710—275 and 1795—294; test bars from the other two ladings were not much below the average. Information on foundry X from writer's observation; on other foundries, from inspectors, corroborated by writer's partial observation in case of foundry Y. Core spindles of all pipes are removed while iron is red, but the earth remains inside the pipes until cut out when the pipes are cleaned. 830" & 20" pipes of this foundry are, however, allowed to stand in the pit, with sand adhering, after flask is removed, till black hot.

Observed Load

THE RISE AND FALL OF THE AMERICAN MERCHANT MARINE.

BY JOSEPH R. OLDHAM, C.E., N.A.

[Read before the Civil Engineers' Club of Cleveland, February 28, 1899.*]

ALTHOUGH for the sake of brevity I have given my paper a general title, the following remarks and statistics refer particularly to the foreign trade, for I opine that few of our community need have much anxiety concerning our lake, coasting and river trade, as these are able to take care of themselves. Hence there is no fall to chronicle in their case.

As regards our foreign trade, the tables supplied by the Commissioner of Navigation do not carry us farther back than 1857, at which date our total merchant marine was practically half a million tons. This tonnage continued to increase up to the year 1861, a very interesting date, no doubt, to many in this room, at which time our total tonnage was 5,539,813 tons. The British tonnage was then 4,806,826 tons (average size of vessel only 171 tons). Notwithstanding the marvelous increase in our lake trade and coasting tonnage, our merchant marine has steadily declined since 1861. At that time the registered American vessels employed in the foreign trade amounted to 2,406,894 tons. The average size of vessel at that precise date I cannot quote, but it was nearly 500 tons, for in 1868 the average capacity of our foreign ships was 485 tons each. I can well remember the splendid American packet ships of those days; for, being the assistant to the chief engineer to the Bureau Veritas, it was my good fortune to be brought in touch with the masters and officers of those fine, swift vessels,—such, for instance, as the “Young America,” “Flying Cloud” or “Red Jacket,”—and often have I heard

Ten jolly tars, with musical Joe,
Heave the anchor apeak, singing “Yo, heave ho!”

In looking back to those times it seems as if some gigantic calamity had stricken our foreign-going ships, and, indeed, the seeming is not far from the real, for, in addition to the disturbing element of civil war on our side, there was an equally disturbing mechanical element acting against us, in the inauguration, by our European friends, of screw propulsion for the ocean trade, which began to be generally adopted on the Atlantic about the year 1860.

When our Civil War broke out, the enterprise and ingenuity

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of American merchants had reached its zenith and had risen to an altitude never before approached in so short a time, but be it remembered that up to that epoch the science of iron construction was in its infancy, and what I may designate as efficient screw tramp steamers were not yet developed.

In 1850 the United States added over 272,000 tons to her merchant marine. The tonnage added by Great Britain and other nations together, in the same time, was only 217,000 tons. It is interesting to relate that, in our trade with Great Britain, the American tonnage entered and cleared in those days was practically two and a half times as great as the British tonnage; but, as soon thereafter as 1867, their tonnage in the North Atlantic trade was three times as great as ours, a marvelous change to their advantage. Still, that was only an initiatory step of an expanding movement that was to be twenty times as large as ours, and to equal seventy per cent. of the total ocean trade of the earth.

I trust I have made fairly clear to you, in a general way, the extent of the *rise* of our merchant marine. Permit me, now, to refer to its fall, and to illustrate the salient features which have contributed to its decay. It was about this time that the Inman Company began to place large iron screw steamers in the North Atlantic trade. Of course these vessels would be considered small for such a trade to-day. I remember the "City of Limerick" well, but the one I had most to do with was the old "City of Baltimore." She was about 300 feet long and her speed was about 14 knots an hour. The Cunard Company, at this time, had the fine old side-wheeler, "Persia," 390 feet in length, carrying the American mails. The "President" and "Pacific," of the Collin's line, were gone, and we had not, and did not have till the "Ohio" and "Pennsylvania" were built in Philadelphia in 1873, a single screw steamer in the North Atlantic trade. By North Atlantic trade I mean anything above 37.30 north latitude. We then had to import iron and also pay dearly for labor, so we were not in a position to build and operate successfully iron steamers to carry our own mails, and no one would then have thought of building an iron tramp, unless a handsome subsidy had been available. Hence the conditions were ripe for the decline of our merchant marine employed in the foreign trade. I have referred to iron screw steamers, and to side-wheelers also, but I have not attempted to show the economy of screw propulsion (which was adopted in 1840) over propulsion by side wheels with feathering floats, because I do not believe that the supposed or actual economy of screw propelled vessels over side-wheelers is due to the propeller.

I state this while thoroughly cognizant of the experimental fact that the slip of the side wheel is frequently double that of the screw, or as 20 per cent. is to 10 per cent. As regards slip, I would say that a medium slip results in no greater loss than a negative slip does in gain. "As a propelling instrument the side wheel is not inferior to the screw," but its speed of revolution is necessarily slow, and side-wheel engines are therefore larger, costlier and heavier than screw engines of the same power. As an illustration, the engines of war vessels develop much greater power when working at their maximum than engines of similar cylinder area in the mercantile marine. This is usually due to greater speed of revolution, and I need hardly remind you that when the speed of a steamer's engines at sea is doubled the power is doubled. If this be so, does it not appear that the economy in coal consumption, which certainly followed the introduction of the screw propeller in ocean steamers, should be attributed to the higher efficiency in working of the steam engines rather than to the propelling instruments? A word about twin screws connected to independent engines, and I have done with this part of my subject. These were adopted by Mr. Dudgeon in 1861, and as early as 1868 were fitted on these lakes to the iron steamer "Philadelphia," of the Anchor Line, at Buffalo, N. Y. Although I admit the necessity for twin-screw engines in vessels of large power, say such as would require a screw shaft of 20 inches in diameter, or over, and in war ships, I maintain generally and presumably—keeping the above exceptions in mind—that there are but two highly efficient types of propulsion,—viz, side wheels for working in a shallow water trade and a single screw for deep water cargo steamers. The necessity for duplicate screws in war vessels needs no comment.

Permit me, for a moment, to draw your attention to one of the first steamboats that visited us from abroad.

The first steamer that ever ploughed the mighty waves of the Pacific Ocean was only as large as the Cleveland tugboat "Harvey D. Goulder," and yet that little vessel traversed some 13,000 miles over two oceans, and then became of inestimable value to the gold seekers of 1845.

The "Beaver" was only 101 feet by 20 feet by 11½ feet; yet, sixty years ago, she made a safe voyage from London to Astoria, Oregon.

The progress in shipbuilding and in marine engineering during the last half of the present century has been, perhaps, more gradual and tentative than is apparent to the casual observer of to-day. In confirmation of this I shall endeavor to point out the

most clearly defined steps in the development of the magnificent specimens of naval architecture to be seen in our seaports at this time. One of the early steamers, of about the same principal dimensions as the celebrated "Great Britain," could barely carry sufficient fuel for a voyage from New York to Melbourne at a rate of speed in smooth water of about ten miles per hour, as this distance could not then have been steamed with less than 4500 tons of fuel. So I will call the dead-weight ability of such a steamer 4500 tons, all of which would be fuel. The change from wood to iron (which commenced about 1840 and became general about 1855) effected, or made possible, an increase in dead-weight ability in ships of like external dimensions—on account of the reduced weight of material entering into the construction of the hull—of fully 20 per cent., so that a ship of 4500 tons burden would carry fully 5000 tons when iron took the place of oak. The actual gain, however, was more than this, for, while the hull was lighter with the same load displacement, it was of still greater internal capacity, and consequently could carry over 20 per cent. more of light goods, such as tea, or cotton, as then stowed. So this change made the exemplary vessel capable of carrying about 600 tons of cargo in addition to her fuel.

Surface condensation became general about the year A.D. 1850, though the principle was patented by Samuel Hall in 1838. This reduced the coal consumption fully 15 per cent. By this step the steamer capable of carrying 4500 tons of bunker coal at the rate of ten miles per hour would have her coal consumption reduced from about 70 tons per day to 60 tons, which on a voyage, say from New York to Melbourne, would leave a further capacity for cargo of about 675 tons; then 600 tons saved in weight of hull and 675 tons saved in bunker coals by surface condensation equal 1275 tons rendered available for cargo by these improvements. The monetary saving by this reduced consumption of fuel may not have been very large, but the cargo capacity gained, and the time and labor saved in handling only 3825 tons instead of 4500 tons, would probably amount to a saving of 5 per cent. of the total cost of the voyage. The following narrative may serve to illustrate the importance of surface condensation.

In the year 1825 the merchants of Calcutta offered a premium of a lac of rupees, which is equal to about \$750,000, for the first voyage of a steamer to India and return averaging seventy days each way. This offer brought out the side-wheel steamer "Enterprise," of 470 tons, and with engines of 120 horse power. Her entire cargo consisted of fuel and stores for an expected run of

thirty days to the Cape, a distance of about 6100 miles. The actual time occupied by the voyage out amounted to one hundred and fourteen days, forty of which were under sail and eleven at anchor. The average speed was five knots an hour. The poor showing of this experiment was almost entirely due to the lack of a surface condenser. Although the speed did not approach that stipulated, the master, Lieutenant Johnstone, R. N., received a present of \$50,000 for his arduous services.

Compound screw engines with increased pressure of steam, adopted in 1854, became general about the close of our Civil War. By this improvement, when the steam rose to 60 pounds, the saving in coal consumption amounted to fully 30 per cent.

In the year 1874 the triple expansion system was devised by Dr. Kirk and fitted in the steamship "Propontis," but the Rowan boiler failed and the multiple expansion system received a setback. Four years after this date, however, it was again taken in hand by Alexander Taylor, of Newcastle-upon-Tyne, and was fitted in the steamship "Isa."

As economy in construction, as well as in propulsion, was a potent factor in building up the rivals of our mercantile marine, I trust I may be excused if I touch on the cost of construction. Forty years ago as much as \$200 per ton was paid in London for the steel with which to build a steamer. Though there is to-day a smaller amount of manual labor represented in a completed ton-weight of a factory or bridge or ship, the relative amount of manual labor, say per ton-weight of material, has not largely varied during any length of time for many years.

In the early days of iron shipbuilding I can well remember that the cost of the iron was about one-third of the total cost of the finished ironwork in the hull, and to-day it is about the same. Steel costs about $1\frac{1}{4}$ cents per pound throughout a ship, or nearly so, and the labor costs about $2\frac{1}{2}$ cents. Thus the former is one-third and the latter two-thirds of the finished structure. Heavy ships may now be built for $3\frac{1}{2}$ cents per pound, but the ratio of cost of labor to the cost of steel does not appreciably vary from the foregoing. In 1878 mild steel was adopted on the Tyne as a substitute for iron in the construction of ships. The effect of this was to augment by about 15 per cent. the carrying power of ships of the same load displacement without loss of strength, as mild steel has about 50 per cent. greater tensile strength than iron. It was not, however, until three or four years later that steel was generally used in the construction of ships. This improvement increased by about 375 tons the dead-weight ability of such a steamer as we are

now considering. (Possibly before the present century closes we shall find a shipowner with sufficient enterprise such as shown by Mr. Henry Clapham, of Newcastle-upon-Tyne, who built the first purely cargo steamer of steel in 1880, to build a ship of nickel steel or other similarly light metal of equal or greater tenacity.) The gain in dead-weight ability by this final step in ship construction would be about 300 tons.

In 1881 multiple expansion engines were started on their onward career by adoption in the steamship "Aberdeen" by R. Napier & Sons. By this system, coupled with improved models and greater efficiency in boilers, augmented piston speed and improvements in feeding and lubricating, the coal consumption has been reduced fully 33 per cent. This would seem to show that about fifty years ago the largest and best steamer afloat could hardly carry sufficient bunker coal to steam from London to Calcutta (about 8000 miles) at an average speed of ten miles per hour even without a ton of cargo on board. To-day, thanks to the higher efficiency of hull, boilers and machinery, if coal could not be obtained on the voyage, a steamer of the same general dimensions as the one referred to could carry fully 4000 gross tons cargo and sufficient bunker coals to steam from London to Melbourne (about 12,000 miles). Indeed, this would not be considered an example of extremely high efficiency in the year 1899.

To summarize, I may say that during the last fifty years steam pressures have gone up from 9 pounds to 300 pounds per square inch,—indeed, I have seen several marine engines working at a pressure of 400 pounds per square inch; piston speeds have risen from 200 feet to 1200 feet per minute. The weight of machinery per horse power has fallen from about 1000 pounds to 200 pounds, and even less; and the coal consumption has been reduced from about 9 pounds to 1 pound per hour per indicated horse power.

Now, taking as an example a steamer such as mentioned, built about fifty years ago, it will be found that all her capacity was required for fuel for a voyage of sixty-four days at ten miles per hour. The steps or gradations towards efficiency in cargo carrying and steaming may be summarized as follows:

1840—To general change from oak to iron hulls effected an increase in dead-weight ability in a steamer 300 x 51 x 29 feet of 600 tons.

1854—To surface condensation lessened the amount of coal required 15 per cent., or 675 tons.

1860—To compound engines, operated by Scotch boilers, lessened the coal required by 30 per cent., or 1147 tons.

1878—To mild steel displaced iron, and increased the carrying capacity 15 per cent., or 375 tons.

1881—To triple expansion, augmented piston speeds, with higher pressure, reduced the fuel required by fully 38³ per cent. This in the foregoing example amounts to 883 tons.

1898—To saving in fuel due to quadruple expansion, improved boilers, feed heaters, etc., 33 per cent., or 520 tons.

1899—To gain in dead-weight carrying capacity during the last half of this century, 4200 tons.

In attempting to apportion the precise amount of gain or advancement due to the adoption of stronger materials or improved types of machinery, permit me to point out that, though the increased efficiency attributed to inventions of a certain decade is mainly due to the improvements named, there are, of course, other causes contributory to the general progress. For instance, when iron superseded oak in ship construction certain so-called adornments and superfluous appendages to the hull and equipment were simultaneously dispensed with. When steel was adopted in lieu of iron for shipbuilding purposes the scientific principles of naval architecture were being extensively investigated and demonstrated. Prior to this period the decks and top sides of ships were lamentably deficient in strength. The bottom, per unit of surface, was twice or three times as heavy as the sides, and could resist a bending moment ten times greater than the deck could withstand. So much more solid material was worked into what I will call the bottom flange than into the top flange of the girder that the neutral axis was frequently 80 per cent. of the total depth below the gunwale, while nowadays it seldom exceeds 60 per cent. I referred to and illustrated this some seven years ago in connection with three Anchor Line boats built under my superintendence.

With regard to the engines, when the two-step compound superseded the single expansion condensing engines the piston speeds were augmented as the pressures rose. In those days of low pressures and velocities there was no better way of doubling the power of an engine than by making an engine of the same size work at double the speed with improved boilers.

In looking at the most perfect steamship of to-day one is led to wonder why she was so long in coming, and to whom the credit is at length due for her appearing. The only reason I can give for the apparent delay is that a multitude of agencies were necessary to the final effect, and of these the most important. Perhaps it would be as difficult to give a full and exact answer to the latter query as to the former, for it is questionable whether more honor

is due to the skilled naval architect or master of engineering, who designs and delineates the great battle ships or greater mail steamers (with rich stores of mechanical science and experimental data to draw from), or to the untutored denizen of the river bank who first dug out the light and graceful canoe or formed the delicate frame of the coracle.

Now that the initiatory steps have been taken towards the construction of a large and deep waterway to the Atlantic Ocean, our lake shipbuilders, shipowners and merchants will probably realize as they have never done before the absolute necessity for some such measure as that proposed by Senator Hanna for creating a large modern mercantile marine. But we are even now in a position to contract with Europeans for steamers carrying from 2000 to 3000 tons, and the average tramp does not carry more than 2500 tons. Moreover, if we can build and export these vessels for as little as they cost in England what would be the use of a free ship measure? I use advisedly the expression "creating," for please bear in mind that at present we have no modern cargo steamers employed in a general foreign trade. The British have many million tons of high-class "tramp" steamers.

With 10,000 miles of the finest seacoast in the world, with the richest stores of iron, coal, copper and wood, with the most bountiful grain and cotton fields, with the greatest and most efficient railroad system on earth, with 75,000,000 of a population, comprising the most intelligent, energetic and intrepid of the Anglo-Saxon race, with our inventive skill and enterprising faculties, such as no other people possess, we succeeded in producing 62,000 tons of steel shipping last year. The British shipbuilding yards turned out not less than 1,500,000 tons in the same time. Indeed, three single British shipbuilders each launch more steel tonnage than we do over our whole coast. For example, Gray, of Hartpool, built 72,323 tons last year; my old friend, G. B. Hunter, of the Tyne, built 68,696 tons; Messrs. Harland & Wolff, of Belfast, built 67,905 tons. In 1897 the latter firm constructed the enormous amount of 84,240 tons.

Nothing is further from my desire than to say anything that would belittle or minimize the enterprise and grand achievements of our shipbuilders and engineers, but when matters have reached their worst the actual facts may as well be known by us; and nothing could well be worse than the figures given in the latest report issued by the Commissioner of Navigation. In that report, on our foreign carrying-trade, he shows that American vessels carried only 25 per cent. of our imports and exports in 1886, and now they carry

less,—viz, 23 per cent.,—while the foreigners' trade has jumped up from 75 to 77 per cent.

Just before our Civil War,—viz, in 1860,—American vessels carried 71 per cent. and foreign vessels 29 per cent. of our imports and exports. I am inclined to the opinion that there is a more or less general impression among those unassociated with shipping that the former deplorable percentages represent our normal condition; that we never were a comparatively great maritime people, and that therefore we should be content to develop our railroads, work our mines, produce our crops, etc., without providing marine transportation, even for our own exports. But such is far from the truth. What we are now endeavoring to attain is only our old status in the shipping world. Just before our Civil War we had a greater ship tonnage than any other nation on earth, and with regard to shipbuilding we then constructed more than the British did. The figures for 1861 were British 208,326 tons *vs.* American 233,194 tons. In 1860 we were adding more tonnage to our mercantile marine than all the rest of the world put together. Last year our "Soo" canal trade exceeded eighteen and a half million tons. These facts should encourage our legislators and others to work for the rehabilitation of our shipping, and how this can be accomplished with as little expenditure and as little loss of valuable time as by enacting Senator Hanna's shipping bill, S. 5024, I have yet to learn or hear suggested.

While that bill is heartily indorsed by those who have studied and realized the degraded condition of our foreign shipping trade, there are some who seem to think that the rehabilitation of our merchant marine is a matter that concerns the maritime community only; whereas it has been clearly demonstrated time and again that the national merchant ships contribute more wealth and provide more general employment to the masses of the people producing and operating them than any other structures of similar bulk or weight.

Let me quote you from a report just issued by the Cairn Steamship Company of one year's work. The net profit of operating six small foreign tramp steamers was \$115,000. After deducting interest, directors' remuneration, income tax, auditor's fees and part formation expenses there was a balance of over \$108,000. The directors recommended a dividend at the rate of $14\frac{1}{2}$ per cent. per annum. The sum of over \$56,000 has been written off for depreciation. The chairman added that out of six vessels, of which the fleet consisted, four had been cleared off for one-third of their original value by the surplus of profits over 6 per cent. The fifth

vessel was also very nearly paid off. Mr. John Price, the chairman of the Cairn Company, is a shipbuilder by trade, and had no early training in the way of managing a steamship company, for prior to his becoming general manager of Palmer's Shipbuilding Company he and the writer were for several years engaged in the same office classing vessels; hence I can speak with confidence of the statements he makes.

It is not the construction of ships that keeps us back, or rather it need not keep us back for the future. But the accommodations for officers and crew on an American steamer are more commodious and better furnished, and the owners find bed and bedding for the men. These conditions all add to the first cost of an American ship, and also to the cost of insurance. It may be true that if tenders were asked to-day for a steamer from our shipbuilders and from those in Europe the latter might be the lower, but then the British alone have over one hundred large steel shipbuilding yards, the average output of each being 15,000 tons per annum. We have twenty large steel shipbuilding yards in the whole of this country, the average output of which was 3000 tons each last year; so we have not the competition or steady work, and without constant employment shipbuilders cannot work economically. This state of affairs cannot be improved without assistance or "compensation" for an initial loss for some years to come, but it is mainly in operating our foreign-going steamers that we are at a great disadvantage. Money is dearer here; higher wages are demanded by seamen. American ship chandlers and others who supply and operate ships charge more than foreigners. Then, the French especially, have so manipulated the international tonnage law that their steamers are worked on a much smaller register, or official tonnage, than ours, and the men, though not paid nearly as high wages as American sailors, are poorly found. The masters get about 30 cents per man per day and "starve the men," as sailors say. Still it is no uncommon thing for the engine room staff of a tramp to retube a boiler while detained in a foreign port and thoroughly overhaul the engines, even to the fitting of a spare crank shaft, without assistance from a shop, especially if there happens to be none at the port.

As regards French commerce, our trade with that nation appears so small that they do not mention America among the six great maritime nations. The principal foreign flags which participated in the French maritime trade in 1897 and the proportionate share taken by each is as follows: British, 41 per cent.; German, 6.3 per cent.; Spanish, 3.7 per cent.; Dutch, 2.8 per cent.; Norwegian, 2.3 per cent.; Italian, 1.9 per cent.

Let the American shipowner be compensated so as to be on an equality with the foreign shipowner, and I venture to prophesy that long before twenty years expire we shall see more than one hundred large steel shipbuilding and marine engineering establishments on the coasts and lakes of this country, turning out, as others are now doing, one hundred million dollars' worth of steamship tonnage per annum.

I intended to write out a detailed comparison of the expense of working a modern American tramp steamer with the actual cost of an ordinary British tramp, but, after tabulating the schedule of the latter, I remembered that there was no such thing in existence as a modern American tramp from which to tabulate average expenses. Mail steamers or regular liners in the coasting trade are not the type of vessel out of which the foreigner makes the money and acquires the balance of trade in his favor. These expensive steamers do not pay as a rule. I think the Cunard seldom pay more than 2 per cent. per annum, and frequently they pay no dividend. But the Newcastle and Sunderland tramps commonly earn from 15 to 25 per cent.

Now, with no Suez Canal trade, with American vessels carrying only about 9 per cent. of our American imports and exports, and without a single modern tramp on the ocean, it is surely time to provide compensation of some kind to rehabilitate our merchant marine. The want of an American merchant marine appears to retard our export trade, for the chairman of the West of Scotland Steel Institute spoke as follows last month:

"The only circumstances which have prevented American steel from competing with the British article more than it has done have been that high freights have been ruling from the other side. When these freights are reduced I understand that large quantities of steel will be exported" (from America).

Now, with reasonable compensation, American steamers could carry our steel and other products at reduced rates of freight to all parts of the world, and thus increase our export trade.

Gentlemen, I have referred to a time that was ripe for the decay of our merchant marine. In conclusion, let me assure you that the time is now equally ripe for its revival, and if that can be realized by this mighty and enterprising nation our harvest of the seas for the future will surely be rich, plentiful and abiding.

DISCUSSION.

THE CHAIR.—This is one of the most interesting papers I have heard for a long time, and I would be glad to hear from any of the members.

PROF. C. S. HOWE.—What is the comparative cost of constructing an American tramp and an English one, and, if we had such, could they afford to pay any dividend under the present conditions?

MR. OLDHAM.—Until the late rise in the price of steel, which has gone up about 50 per cent. I believe, there was very little difference between the cost of the same class of tramp here and in the old country, but we cannot build as economically unless we have a regular trade. Our shipyards are idle for one-fourth of the year, but if we had constant employment, which can only be obtained by remunerating the shipowner for some time, this could be accomplished. When the state of affairs becomes normal we can build hulls cheaper than they can in the old country; and after our brokers become accustomed to lower profits, and when we have a better consular service, we might have an American ship as cheaply built as a British ship; but if we go to a foreign port we find that there is no one to look after our interests, and the ship might have to lie for weeks without a charter. That is where the loss comes in. It is generally foreign trade that pays. We can build ships with equal accommodations with the English, but our men are accustomed to better accommodations. These will have to be reduced, and I am afraid the living will also have to be reduced. Senator Hanna suggests a good way to compensate the shipowners.

MR. B. L. GREEN.—What is covered by the $3\frac{1}{2}$ cents per pound; does it cover simply the steel work of the vessel? Also, what is the most economical tonnage for a tramp steamer? Is it about 5000 tons, and does the construction per pound of tonnage decrease or increase beyond that tonnage? Will great vessels come into freight service? Is your table of comparative tonnage comparable with the report of the Maritime Congress of Paris?

MR. OLDHAM.—The $3\frac{1}{2}$ cents refers only to the hull; it is the cost of the steel and the working of the steel into the ship. About 6000 tons is a fair average, although some are as high as 12,000 tons. The cost of construction becomes lower per ton as the size increases. I think the "Oceanic" will cost less per ton than smaller ships. I do not remember much about the French maritime report.

MR. GREEN.—Is there something, as regards peculiar subsidies, which makes it easier for a vessel hailing from England to do business than one from the United States?

MR. OLDHAM.—It is altogether false that the steamers are assisted by the Government. They are harassed by the Government. The British mercantile marine receives no assistance from the Government except that of an excellent consular service. As for the mail steamers, they receive a big subsidy for mails, but this

is to compensate them for delays. Mail steamers sometimes have to wait a half-day at Queenstown, in crossing the Atlantic, waiting for the mails.

MR. J. N. CULLEY.—What is a tramp steamer?

MR. OLDHAM.—It is a steamer which takes a charter to go anywhere. It is not a regular liner in any way.

MR. W. H. SEARLES.—It is rather humiliating to perceive that the tonnage of the United States has declined for so many years and to so great an extent while the tonnage of the world has been rapidly expanding. The weight of sea-borne commerce has increased eightfold in the last fifty years, and the best authorities on this subject predict that it will at least double itself in the next fifty years. If we expect to enjoy any reasonable share of this enormous traffic it is high time that we bestir ourselves. The average size of steamships is also constantly increasing. The old "Great Eastern" of 1860 was thought a monster in that day, yet now a regular liner is building which greatly exceeds it in every particular. The larger the vessel the greater is the economy of transportation, and the only limitation in size at present is found in the ports and channels which the steamers must use. Liverpool, after having repeatedly enlarged its facilities to accommodate the increasing size of steamships, is now widening and deepening its docks to accommodate vessels up to 900 feet in length, 90 feet in beam and 36 feet in draft, and is expending at present \$17,000,000 on these enlargements.

Improvements in progress on this side the Atlantic will give a low tide channel of 30 feet to Philadelphia and Boston and Galveston, and of 35 feet at New Orleans and New York.

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THE PRODUCTION OF SEAMLESS TUBING.

By H. S. WILSON, MEMBER, ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, February 1, 1899.*]

THE first thing to consider in preparing to make seamless tubing is the kind and quality of the steel best adapted to the purpose. Up to within two years such steel could be obtained only in Sweden and Norway. The ore used is of two kinds, a very pure hematite and a rich carbonate, and the lime used, owing to its semi-Arctic origin, is very low in phosphorus.

It is absolutely necessary that the percentage of elements of phosphorus and sulphur be as low as possible. The sulphur in fact must be present only as a trace. The mines are situated nearly on the border between Norway and Sweden, and have been for years a source of immense revenue to both countries. The steel is there produced in open-hearth furnaces of about five tons capacity, and the processes are carried forward, as far as possible, with the use of charcoal as a fuel. I was unable to secure any of the charge weights at the blast furnace, but presume they are about the same as would be good practice here.

One of the facts developed is that metal of the right quality cannot be made in large hearths, about five tons or twelve thousand pounds being the limit. Apropos of this I will relate a circumstance occurring under my own observation. Among a lot of 500 tons of steel bought from one firm, through a New York agent, occurred one group of 200 bars. These bars being put to

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our ordinary tests and analyses seemed all right. They also passed all the hot processes creditably, but the first piece that reached a cold drawing bench gave a yowl that woke up every one from the manager to the errand boy. As no thought of the steel being otherwise than good had occurred, the foreman of the annealing room received my immediate attention.

Repeated trials under my personal supervision brought no better results, and it was only by a graphic demonstration in the presence of the agent that I could convince him that the steel was not right. When the history of the steel was traced to its origin, it was found that it had been refined in a new furnace of American design having a capacity of fifteen tons.

A Pennsylvania firm made and sent us many samples for trial, but after a long series of failures they started in on the same basis which Swedish practice had proved to be efficient, dropping their American ideas of melting a whole mountain at one heat, and refined in a small furnace taking a charge of 13,000 pounds.

The very first sample proved fully as good as the foreign make, except in tensile strength. For tubes of large diameter it even worked better. One of the finest lots of tubes that were produced were from this first lot of steel, and were for the inner barrels of the famous dynamite guns sent to Cuba.

The dimensions were,—outside, $3\frac{1}{2}$ inches; inside, $2\frac{1}{2}$ inches; length, 16 feet; carbon, .30; ultimate strength, 67,000 pounds; limit of elasticity, $22\frac{1}{2}$ per cent. Tests all made annealed.

Assuming that we have our material satisfactory, the hollow billet, or the "How do you get the hole in it?" problem comes next. Let us take the oldest methods and follow through the various changes in later use. The first Swedish billets were cast hollow, and then reduced in "fore and after" grooved mills.

These rolls were arranged with a beam for rolling on the rod and also for rolling off from the rod. By reference to the sketch you will note the position of the billet and bar in the before process. In this instance the rod or bar is placed in the hole first and the reduction made away from the beam, leaving the bar out of the hole when the pass is complete. This is all right when the tube or billet is thick and will hold its heat, but later when they get thin this would not do, as the rolling must be accomplished with considerable celerity to be successful. You will note in the after way, which is most common, the tube or billet is rolled on the bar and is removed by drawing the bar forward. A loose plug of high manganese steel furnishes the stationary medium for the inside diameter.

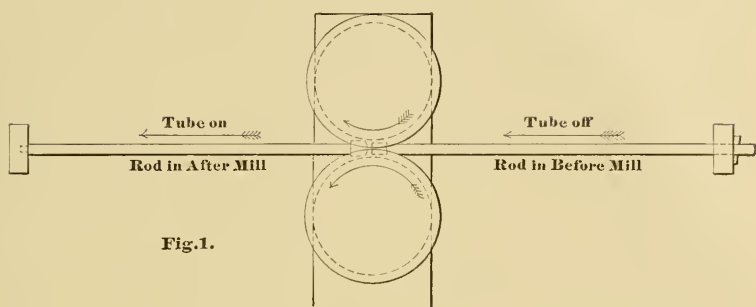


Fig. 1.

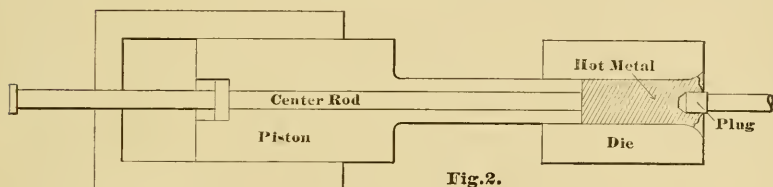


Fig. 2.

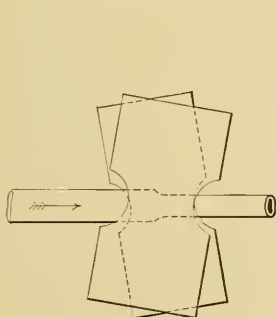


Fig. 3.

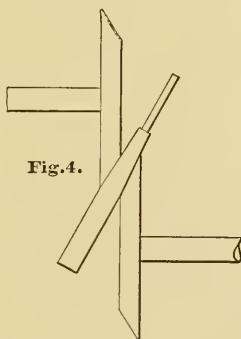


Fig. 4.

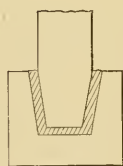


Fig. 5.

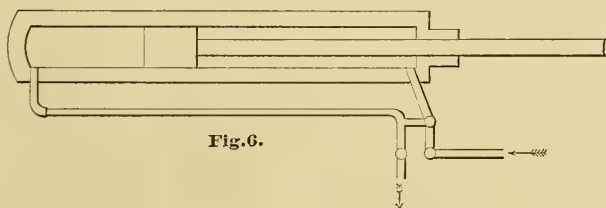


Fig. 6.

As the ordinary billets come from Sweden they are of $3\frac{1}{2}$ inches outside diameter and $2\frac{3}{4}$ inside, varying in length from 10 inches to as many feet. The casting method being very expensive owing to imperfect casts and costs of molds and cores, recourse was had to some method of punching or piercing a hole through the solid ingot.

The oldest way consists in forcing a hexagon ingot 12 inches in diameter over a 6-inch mandrel. The machines are powerful hydraulic affairs. You will note from the sketch that the block of steel is forced out through a bell-shaped opening. The steel plug is loose and goes through and into a slight opening in the ram. There is an auxiliary plunger passing into the end of the main plunger, which at the proper moment allows the plug to be received, and then discharges it and the small "biscuit" of steel which has been punched out. The plug of course is somewhat larger than the bar or punch, which provides a safer clearance for the discharge of the pierced billet. All the further reductions are carried forward on the "fore and after" mill already described, and the billets are sawed hot to the proper length. Tubes called stock tubes can be had which are ready for the cold reduction processes. These tubes are from $2\frac{1}{2}$ to 2 inches diameter, and from 5 to 10 Birmingham gauge, weighing $17\frac{1}{2}$ to 35 pounds.

One of the most interesting processes is that of the Mannesmann Bros., which makes use of a curious phenomenon as well as the fact, that the weakest point in a bar of steel is at its center. The Mannesmanns did not invent this process, but discovered it.

They were trying to construct a mill for cold rolling steel, hoping by the arrangement of the rolls shown to roll a perfectly round straight bar. For this purpose the mill was a perfect success, and as the bars of rough steel were rather irregular the idea was developed of trying the method on hot work, which it was hoped would save one annealing of the stock and much wear on the finely finished concave rolls. At first, of course, the steel was secured only a fraction of an inch larger than wanted. Wishing some stock one day, much smaller than any on hand, they concluded to roll some down, and incidentally to see how much reduction could be made at a pass. The first pass produced a bar of steel with a hole entirely through it, and thus the so-called Mannesmann process became a fact. The phenomenon is explained by the tendency of masses of steel to remain weakest at the center, and also the fact that all the different molecules of the metal travel at a different velocity. You will note that the angular position of the rolls causes the bar to have both a rotating and longitudinal motion, the sum of the two producing a spiral.

Also the part which has passed through the rolls, owing to its smaller diameter, revolves faster than the larger portion, thus giving to the mass a wringing motion, causing the center to become separated and forming an opening, which in practice is enlarged slightly by holding a stationary bar against the end. After being pierced by this method, the billets are further reduced by a mill having a spiral in the opposite direction, and finally by an after mill as before explained.

A modification of this system is the so-called Stiefel process, in which exactly the same result is produced in a modified manner. I will state that this process was copied by Mr. Stiefel from one already in use in Sweden. You will observe that in this instance we have two slightly beveled disks and that the solid ingot passes through in a diagonal direction. Going further, note that the large diameter of one disk opposes the smaller circle of its fellow, and the result of this is to produce the identical wringing motion before noticed. Added to this is the high velocity of the moving parts, causing centrifugal force to assist in the operation. Use is made here also of a bar for smoothing out the inside of the hole.

Additional features consist of a pair of segmental rolls, having tapering grooves which, by a succession of squeezes, stretch the metal along a bar. As an illustration, you can compare this process to what would occur should you squeeze a piece of putty along your finger by the use of the other hand. After the metal has been extended it is afterwards stripped from the bar by a very heavy chain bench.

There are yet one or two more special processes of producing hollow billets. The one practiced at the works of the United States Projectile Company, in Brooklyn, deserves notice. In this method a short block of round steel is placed in a conical mold and a tapering plunger forced down into it, producing a cup-shaped piece, from which, by successive draws through dies and over mandrels, a $3\frac{1}{2}$ -inch tube, closed at one end, is produced.

From this the tubes are sent to a hammer to have a square tag forged on the closed end, and the open end also has the ragged edges trimmed or cut off. After being further reduced by drawing hot through a succession of gradually decreasing dies to the usual size of $2\frac{1}{4}$ inches, they are ready for cold drawing. This all sounds very simple, but it is not. First, there is the hydraulic plant developing a pressure of 2500 pounds to the superficial inch, and driven by an engine of 1500 horse power. Then there is the material composing the dies, mandrels, taper plungers, etc. Quite an item to consider is the packing to stand any such pressure. I can only

touch briefly on these items, as to go into all the details would consume more time than I am allowed for this paper.

For the short tapering plungers in the initial operation nothing has been found to replace a good quality of gray iron. The conical die is also of the same material. For the longer mandrels, tool steel of rather low carbon gives the best result, a preference being given in favor of the alloys of chrome. The dies are cast in a special chill mold and are of a composition of cast steel, scrap gray iron and ferromanganese.

This material is about as hard as chilled iron and must be ground to a finish. It is customary to lubricate all the hot tools with a composition of black oil and graphite. I have forgotten to mention that a special stripper is placed just below the dies in the second operations.

In the working of nickel steel as carried out by the Pope Manufacturing Company, at their works in Hartford, Conn., the billets are secured by drawing a circular plate about 14 inches in diameter and 10 gauge, the process being exactly the same as making a cartridge shell, by a succession of draws from a primary cup about 8 inches in diameter, about one-tenth being included in each draw after the first.

We have now reached the point where our troubles are to begin, and one of the first as well as almost the last thing is the proper way to anneal. We can anneal with muffles, both sealed and unsealed. We can use the slow process and soak them or the quick process and cool them in the air. We can use the heat direct or we can radiate,—either reversing, direct, or reverberating.

We can use for fuel hard coal, soft coal, wood, gas, coke or oil with natural or forced draft either by steam or air, and lastly we can spoil more tubes right at this point than is usually conceded. As all the foregoing methods are in everyday use, I will briefly mention them in succession.

When this industry was in its infancy, all tubes were annealed in close circular muffles, bringing the whole to a good bright red and allowing to cool in the open air. Later they were soaked,—that is, put in a pit and allowed to cool very gradually.

One American method consists in filling the muffles with gas or any non-oxidizable substance which prevents scaling and the excessive use of acid in pickling. Pickling is even dispensed with, but with very doubtful results.

The English method as practiced in Coventry consists in making a very large furnace which is fired with producer gas, heat being developed very slowly, and the charge cooled to a black

before it is drawn. The tubes are quite soft and pickle quickly. At Shelby, Ohio; New Castle and Ellwood, Pennsylvania, the latter method is in use, with the exception that coal is the fuel.

In the open hearth annealing the very best results are realized at the works of the Projectile Company. By their system the tubes are laid out flat on a hearth only one high when thin, and two high when of large diameter and thick walls. The fuel is gas coal with forced air draft. The flame passes just above the tubes and radiates the heat required. To anneal a charge of $1\frac{1}{2}$ -inch No. 16 takes only about 10 minutes. The tubes as soon as heated are thrown off the hearth into an iron truck kept in a closed lower compartment of the furnace, where they cool sufficiently before being drawn out. At one time they used oil as a fuel, but it imparts to the tubes a peculiar scale or coating very hard to remove in the pickle.

Having properly annealed the billets, we advance to the process of pickling. This is accomplished by immersing the tubes in lead-lined tubs containing a hot solution of sulphuric acid and water, about one of acid to thirty of water by weight. The proportions, however, are not important when the bath is new, but when it becomes impregnated with iron more strength is required.

After a period of from ten to twenty-five minutes the tubes are found to be of a uniform dull gray and are then washed and dried. This drying is the important feature in the whole process. Unless it is done many tubes cannot be drawn, and furthermore the temperature at which the drying is carried on is of vast importance.

It must be that which will boil sulphuric acid, or a little below 400° Fahrenheit. At this stage is reached the place where we will either make a great noise over a failure or keep very quiet over success. If the tubes are not soft they will surely break or destroy the tools. If not properly dried they will wail their objections to the whole thing, giving off a series of grunts and howls that can only be appreciated when heard.

Supposing, however, that all has been right to this point, let us consider the machinery and tools employed in cold drawing as well as the *modus operandi* and the proper reductions to produce success.

First, of course, come the benches. When Mr. Stephen True-mann was imported to this country by Mr. Losier, he naturally built an English mill at Shelby, Ohio. Here are to be seen in long lines more than a hundred heavy chain benches traveling at a speed of from $15\frac{1}{2}$ to 20 feet per minute, with tongs for gripping the tube, die block and tail piece for holding the rods. The illus-

tration will, I hope, make the matter clear. The tube is placed on the rod and then the end stuck through the die, the tongs hooked in and the tube pulled between the stationary end of the mandrel and the die, reducing both the diameter of the tube and the thickness of the walls.

I have in the foregoing neglected to state that the tubes are first oiled by immersing in a tank of black oil and drained off by setting them on the open end. The principal constituent of this oil is the so-called oil asphalt,—a residue from the refining of illuminating oil. I have to show you only two samples, one a finished piece of tubing and the other a section, showing the exact effect of the drawing process. You will observe by the use of the micrometer the reduction in thickness between the two ends of the larger sample. To produce a piece of $1\frac{1}{8}$ -inch No. 22 tube requires the following reductions, the annealing and pickling coming between each draw:

At the point marked with the heavy line the tubes must be cut in two and retagged, or rather they must be cut to weight, which in this instance is 5 pounds, producing when finished about 15 feet of tubing.

TUBES.

Dimensions of billet $2\frac{1}{4}$ or 2.250 inches, and the two walls equaling .350.

	Die.	Plug.	Walls.
First pass	2.12	1.87	.250
Second pass	2.04	1.84	.200
Third pass.....	1.97	1.81	.160
Fourth pass	1.90	1.77	.130
Sink	1.80		
Fifth pass	1.76	1.63	.130
Finishing	1.62	1.59	.130
	1.666	1.55	.116
	1.608	1.51	.098
	1.554	1.47	.084
	1.500	1.43	.070
	1.454	1.39	.064
Sink		1.35	
	1.314	1.25	.064
	1.266	1.21	.056
Lime—sink		1.16	
Finish draw	1.125	1.061	.056

You will note in the table of reductions the words “sink” and “lime.” By sink is meant the reducing of the outside diameter, only made necessary in order that the finish draw may produce a tube of exact diameter and thickness. Lime is intended to indicate to the pickler that the tubes must be limed or washed in lime-water after pickling.

The application of lime prevents the formation of iron peroxide, which would leave the tubes a very dark brown or nearly black. In drawing the tubes cold care must be taken not to do

too much sinking, which produces a rough interior and a tendency to split or crack along their length. This is one of the reasons why tubes of small diameter and thick gauge so frequently split in working. As it is not practical to use a rod of less than $\frac{3}{8}$ -inch diameter, the sizes must be reduced only from the outside, entailing much care in both the annealing and drawing.

When the rods are of tool steel and all is well the tubes slide through the dies with the greatest ease, but sometimes they do not,—they break; they scratch; they chatter, causing a succession of ridges along the tube, and in fact they sometimes have moods, when patience to overcome the difficulties is more than a virtue.

Breaking may be the result of inequalities of density traced to careless annealing, or they may have been heated too hot, which changes the nature of the steel. Also the rod may stretch, and it is rather a strange thing to see for the first time a $1\frac{1}{2}$ -inch steel rod stretch out like a rubber band.

Scratching both inside and outside is the result of improper tools. The dies for roughing are best made of composition, principally ferromanganese, softened or toned with gray iron and steel.

For the drawing dies for finishing, a medium grade of chrome steel will answer. These dies and plugs are made as hard as fire and water will produce, using as a quench a solution of rock salt and water containing about 5 per cent. of sulphuric acid. Most hardeners use cyanide to protect the surface and a gas furnace in which to heat. The shape of the dies makes some difference also in the result.

One way is to use a die whose working surface is part of a circle. This form is short-lived and productive of mixed lots of tubes; that is, the tubes will vary much both in diameter and thickness. My own experience is that a parabola produces more uniform results than any other form of working surface. In order to render an exact adjustment, the plugs are made about $1\frac{1}{2}$ inch in length of working surface, and are tapered from three to five-thousandths in their length. All the tools must be constantly watched and cleaned, and so severe is the strain or pressure that, notwithstanding their hardness, small particles of metal will adhere so firmly as to require filing for their removal. Chattering may result from one of two causes,—too elastic rods or the presence of free acid on the surface of the metal. The remedy for the first is stiffer rods, and for the latter another baking in the dry oven. There are a number of variations to be spoken of in the line of cold drawing. There are several methods of lubrication. You can draw tubes with soft soap, to which has been added a little free

animal fat. You can also lubricate them with flour paste, containing a large percentage of tallow.

Both of the latter ways do away with drying the tubes. Neither of them, however, are as rapid as the oil system, requiring dry tubes for success. At the Projectile Company we used hydraulic benches, operated by means of differential cylinders, and I think it will be interesting to some to explain the details of the differential bench. First, you will note that the piston rod is nearly half the area of the cylinder. Next observe that the valves are arranged for three positions. First, pressure cut off from either end; second, pressure on both ends and the exhaust closed, and third, pressure at the front, with exhaust open.

Thus in use, to cause the bench to travel away from the die, the third position is operative. To return the bench or tongs to the starting point the exhaust is closed and pressure turned on both ends of the cylinder, in which case the difference in area between the two ends will cause the piston to travel away from the greatest pressure and towards the less resistance.

This motion or differential action is what gives the machine its name. There is a great saving of power, as the piston makes one round trip, with only one cylinder full of water. If direct pressure were used at either end, the total contents of both ends would be required to reach the same results. It is hardly necessary to note that the first position of the valves will cause the bench to stand still, unless there should be a leak, which is of frequent occurrence. The dimensions of the cylinders were varied according to the work. Roughing benches for the heavy pulls incident to the first five or six passes were 8 inches inside, with $3\frac{1}{2}$ -inch piston rods, and were of steel forged tubes $1\frac{1}{2}$ inch thick. Light benches for finishing were $5\frac{1}{2}$ inches inside, 2 15-16-inch piston rods and 17 feet in length of clear stroke.

We had one bench which was nicknamed the "Long Tom." On this we could draw to a finish a tube 4 inches outside, $2\frac{1}{2}$ inches inside and 18 feet long. This bench was 10 inches inside diameter, with a 5-inch piston rod. Such trifles as a steel tag $1\frac{1}{2}$ inch square on the end of a tube were right in line for rupture, and when they broke gave off a report like the discharge of a gun.

While the Pan-American delegates were visiting the factory, we amused them by breaking in two 2-inch square steel of low carbon which, having a high extension limit, made a very nice exhibit of candy pulling.

After the finish draw the tubing must be straightened, inspected for defects, the ends sawed off, and then it is ready for

shipment. Such in brief are the mechanical features of the process, but there are others. To make up the usual stock of tubing carried for bicycle purposes requires 61 varieties of tubing, not including D shapes, triangles, ovals and other special shapes.

Also there may be several kinds of steel in process, all of which entails the utmost care in arrangement to prevent errors. All steels look alike under such circumstances, and as there are on the average about 14 reductions to each variety, the net result is that from five to six hundred varieties of tubes may be in the works at the same time. To avoid any ordinary mistakes, I devised a system which gave us at all times complete knowledge and control of every lot of tubes. Each and every lot or truck load of tubes of about half a ton's weight was numbered and had wired to it a large brass tag.

When these lots were first numbered there was made out a corresponding tag of paper, having in addition worked out on its face the consecutive reductions or draws from start to finish. This tag was sent to the tool room, and hung with hundreds of others in several long rows. The moment a load of tubes came into the bench room from the pickling department, or drying ovens, the boy whose duty it was to get the tools simply looked at the number, and then secured from the tool room the next set of tools to be used on that lot, and that draw was checked off from the paper tag to show that it had been given out.

Each and every person handling tubes was provided with time cards, and put on his card all the numbers passing through his hands during the day. By this system we always knew where the tubes were and had the name of every one who had in any way helped to finish or carry forward the work. We also knew the exact amount of reductions on every piece or lot of tubes throughout the entire process. To produce good tubes homogeneous in texture, high in tensile strength and free from defect requires the utmost care. You are always working between good and evil, as when you give the tubes a good reduction pull you improve or at least keep the original conditions; but when you sink them or simply reduce their diameter you lower the conditions of excellence. If you were to take a $1\frac{1}{2}$ -inch tube, 24 gauge, and give it a succession of sinks, no matter how carefully you annealed it, you would have only ribbons by the time you reached half-inch in diameter.

The usual test consists in bending a piece of 1-inch No. 20 tube, annealed, by placing it between two supports or fulcrums 12 inches apart, placing the weight or pressure midway, or 6

inches from each support. Under such circumstances, such a piece of 1-inch tubing will sustain a weight of more than 800 pounds, sometimes as high as 910 being registered. The tensile strength is usually about 67,000 pounds.

At this point I wish to note a curious fact, which I noted years ago at the works of the Washburn Moen Co. in Worcester, Mass. It is a popular notion, and I believe is incorporated in most of the text-books on the subject, that steel wire increases greatly in strength when subjected to several reductions by cold drawing. I wish to state that such is not the case. Take two samples from the same bar and cold-draw one as much as you please. If you anneal the undrawn one as many times as the other, and conduct the tests in an annealed state, not 5 per cent. difference will be observed. But of course, if you test the wire that is drawn with the temper in it as it comes through the die, it will be much higher in tensile strength, but lower in extension. Exactly the same thing occurs in the making of tubing. The metal is refined, but when annealed is but little stronger than before drawing. Tool steel also improves every time it is properly annealed, and many a fine piece of tool work is cracked and spoiled because the steel was not annealed as thoroughly as it should have been.

But I am afraid I am digressing from my subject. It might be well to add a few things before closing on other kinds of seamless tubing besides steel. The squirting or ejecting of lead pipe is, I believe, too common to need any explanation. Seamless copper tubing is made by casting a hollow or ring cake and then drawing the tube much the same as you would steel. As copper can be worked hot, the work can be handled very rapidly, the last reduction being of course cold on ordinary benches in the usual manner. Brass tube, however, needs some special consideration.

There are three ways to produce seamless brass tubes. One is to cast a hollow tube and reduce by successive cold draws in powerful hydraulic benches. As all brass must be scraped to produce a clean surface, the brass ingots are both bored out and turned off after the first pass or reduction.

In France I saw tubes produced by piercing a solid block of brass exactly as tubes are produced from steel in Sweden. The Mannesmann process will also work both on brass and copper.

The Randolph & Clows Co. make tubes by shell reduction, similar to the method employed by the Pope Manufacturing Co. in making nickel steel tubing. For brass the lubrication is with weak soft soap.

I would have gone into details somewhat more extensively had time permitted. My explanations have, I hope, been sufficiently clear to enable you to form a fair idea of not only "how they do get the hole through the steel," but also how both the hole and outside are afterwards finished.

CHEMICAL TESTS OF CEMENT.

BY JOHN F. WINFORD, CHEMIST OF ST. LOUIS WATER DEPARTMENT, AND
S. BENT RUSSELL, MEMBER OF THE ST. LOUIS ENGINEERS' CLUB.

[Read by abstract May 3, 1899.*]

IN this paper will be given the method of testing cement used in the St. Louis Water Department chemical laboratory.

All Portland cement used in the water department work is analyzed for sulphuric acid, magnesia and sulphur in sulphides. Each of these constituents is held by some authorities to be deleterious if present in excess of a certain proportion. The importance or necessity of such tests will not be discussed herein. There is, however, in the latest specifications used by the St. Louis Water Department the following clause:

"If a sample of the cement shows by chemical analysis more than 2 per cent. of magnesia (MgO), or more than 2 per cent. of anhydrous sulphuric acid (SO_3), or more than one-fourth of 1 per cent. of sulphur as sulphides, the shipment will be rejected."

In inspecting cement for the department a great many determinations of these elements in cement have been made, and especially of magnesia and sulphuric acid. The experience gained in this way has shown that certain precautions are necessary in making the analyses in order to get accurate results. When the rejection of a large shipment of cement and, to a certain extent, the local reputation of a manufacturer's brand depend upon the analysis, one cannot afford to have doubtful results.

No claim is made for originality in the methods used. It is believed, however that there is no published scheme for such tests which covers all the points that come up in making tests of this kind with Portland cement.

Below will be found a detailed account of the operations made for such determinations. No attempt is made to show the reasons for the different operations, and so it may seem to the reader that unnecessary attention is given to some of the details. The beginner is therefore warned to be cautious in departing from the path laid out.

DETERMINATION OF ANHYDROUS SULPHURIC ACID (SO_3) COMBINED AS SULPHATE IN CEMENT.

Place the sample on a flexible cloth or paper; crush any lumps with a spatula; mix thoroughly by rolling, and spread out uniformly. Scoop up portions of the cement from points distributed

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over the whole sample; place in a Wedgewood mortar and powder. The portion scooped up should weigh about 150 grams. After powdering place on a glazed paper, mix by rolling and spread. Weigh out 10 grams by dipping up portions from different parts of the sample. Place the 10 grams in a porcelain dish 5 inches in diameter and run 100 c. c. of distilled water into the dish. Stir up the cement and water and add 50 c. c. of strong hydrochloric acid. Lay a glass triangle on the dish, and on the triangle a convex cover glass 6 inches in diameter; place on an asbestos board over a Bunsen burner and evaporate to dryness, or until there is no longer any odor of hydrochloric acid. Remove the burner; allow to cool. Remove the glass triangle and place the cover glass directly on the dish. Run in 50 c. c. of concentrated hydrochloric acid, replace the Bunsen burner and heat to boiling. Add 100 c. c. of distilled water and allow to boil five minutes. Rinse the cover glass with a jet of distilled water into the dish. Filter while hot, using a filter pump and a No. 0 Munktell's Swedish filter, 15 cm. in diameter. Wash the insoluble residue from the dish to the filter by means of a jet of hot water. Wash the insoluble residue on the filter three times with hot water. Pour the filtrate and washings into a No. 5 Griffin beaker, cover with a convex glass, bring to a boil on a wire gauze over a Bunsen burner, add 20 c. c. of 10 per cent. solution of barium chloride, remove the Bunsen burner and allow the precipitate of barium sulphate to subside. Filter on a No. 0 Munktell's filter 9 cm. in diameter, using the filter pump. By means of jet of hot water wash the precipitate from the beaker to the filter, and wash the precipitate on the filter with hot water three times. When the washings have run through the filter, and before the filter is dry, place the filter with the precipitate in a weighed platinum crucible. Cover the crucible and place on a triangle over a Bunsen burner; heat at a low temperature until all the moisture is driven off. Remove the lid from the crucible; place the crucible in an inclined position on the triangle, and arrange the cover so that it projects partly into the crucible and rests on the rim of the crucible and the triangle. Heat to redness until the filter is completely burned. Remove burner, allow to cool and weigh crucible with the ignited precipitate. The difference between this weight and the weight of the crucible gives the weight of barium sulphate, which, multiplied by 0.3433, gives the weight of anhydrous sulphuric acid in 10 grams of the cement. The weight of the anhydrous sulphuric acid multiplied by 100 and divided by 10 gives the percentage of anhydrous sulphuric acid (SO_3) in the cement.

DETERMINATION OF SULPHUR (S) COMBINED AS SULPHIDE IN CEMENT.

Of the sample of 150 grams, prepared as described under "The Determination of Sulphuric Acid," weigh out 5 grams and place in a flat-bottom flask of about 300 c. c. capacity. Insert a doubly perforated rubber stopper into the mouth of the flask. Through one of the perforations extend nearly to the bottom of the flask a globe-shaped funnel tube having a Geissler stopcock and ground glass stopper. Through the other perforation pass a glass tube bent at right angles and extending just through the stopper. To the outside of this tube connect, by means of a piece of pure gum tubing, a Will & Varrentrap's three-bulb nitrogen apparatus containing 1 c. c. of liquid bromine and 25 c. c. of strong hydrochloric acid. Allow 100 c. c. of distilled water to run into the flask through the funnel tube while gently shaking the flask. Close the stopcock of the funnel tube and put 50 c. c. of strong hydrochloric acid in the globe. Allow the acid to pass into the flask gradually by opening the stopcock. When it has all entered flask close the stopcock and insert the glass stopper in the mouth of the globe. Heat the flask now gradually to boiling, and boil until the acid in the nitrogen bulbs gets warm. Detach the bulbs from the apparatus; run the contents into a No. 3 Griffin beaker and wash out the bulbs into the beaker three times with distilled water. Cover the beaker with a convex glass and set to boil over a Bunsen burner. Continue the boiling until all the bromine is driven off. If the liquid is not perfectly clear filter through a No. 6 Munkell's filter paper 9 c. c. in diameter into another beaker of the same capacity. Wash the filter twice with distilled water; set the clear liquid to boil again, having covered the beaker with a convex glass, and add 10 c. c. of 10 per cent. solution of barium chloride. Remove the burner and allow the precipitate of barium sulphate to subside. Proceed now with the precipitate exactly as described under the "Estimation of Anhydrous Sulphuric Acid" until the weight of barium sulphate is obtained. When this weight is obtained multiply by 0.1374, which gives the weight of sulphur as sulphide in 5 grams of cement. Multiply the weight of sulphur as sulphide by 100 and divide by 5 and the result will be the percentage of sulphur as sulphide in the cement.

DETERMINATION OF MAGNESIA (MgO) IN CEMENT.

Of the 150 gram sample, obtained as described under the "Determination of Anhydrous Sulphuric Acid," take 10 grams from different parts of the sample, place in an agate mortar and grind

exceedingly fine. Place on a glazed paper, mix and spread out evenly on the paper. Weigh out very accurately 1 gram of this fine powder taken from points distributed over the sample; place in a porcelain dish $4\frac{1}{2}$ inches in diameter, add 50 c. c. of distilled water and stir up the cement; add 25 c. c. of strong hydrochloric acid while stirring. Lay a glass triangle on the dish and a convex cover glass 5 inches in diameter on the triangle. Place the whole on an asbestos board over a Bunsen burner, evaporate to dryness or until no further odor of hydrochloric acid is given off. Remove the burner, allow to cool; remove the glass triangle and place the convex glass directly over the dish. Add 25 c. c. of strong hydrochloric acid and heat to boiling; run in 50 c. c. of water and allow to boil for five minutes. By means of a jet of distilled water rinse off the cover glass into the dish. Filter immediately on No. 0 Munktell's filter paper 9 cm. in diameter, using the filter pump. Wash out the dish by means of a jet of hot water, and allow the washing to run through the filter. Wash the filter and precipitate three times with boiling hot water. Pour the filtrate into a No. 4 Griffin beaker, cover with a convex glass, add ammonia in slight excess and boil until only a slight smell of ammonia comes from the liquid. Filter immediately, following exactly the instructions given in the preceding operation of filtering. Remove this filtrate to a No. 5 Griffin beaker, cover with a convex glass and heat until boiling briskly on a wire gauze over a Bunsen burner. Run into the boiling solution by means of a pipette 50 c. c. of ammonium oxalate solution containing 1 gram of the salt to 24 grams of water. Allow to boil five minutes; remove the burner and allow the precipitate to subside slightly, but before the liquid cools much filter through a double filter (Munktell's No. 0, 12.5 cm. in diameter). By means of a jet of boiling hot water wash out the beaker, holding in such position that the washings run on the filter, and continue until the filter is full nearly to the top. After allowing the washings to run through the filter, repeat the operation twice. Pour the filtrate into a No. 6 Griffin beaker, and if it is not over 250 c. c. in volume allow to cool; if it is over 250 c. c., evaporate to this volume or to 200 c. c. in a platinum dish and replace into the beaker. This filtrate should be absolutely clear, and if not should be refiltered until it is clear. When the clear filtrate is cold 100 c. c. of strong ammonium hydrate are added and 25 c. c. of a 10 per cent. solution disodium hydrogen phosphate. The liquid is then stirred briskly with a glass rod capped with a piece of pure gum tubing at its lower end. The beaker is then covered with a convex glass and allowed to remain at rest in a cool place for twelve hours.

Filter on a No. 0 Munktell's filter 9 cm. in diameter, using the filter pump. Wash out the beaker with a cold solution made up of 100 parts of strong ammonium hydrate, 20 parts ammonium nitrate and 300 parts of distilled water, allowing the washings to run through the filter. Then by means of a jet sprinkle the side of the beaker with this same solution and rub with the gum cap on the end of the glass rod. Wash the beaker again to the filter. Wash the precipitate on the filter four times with the solution of ammonium hydrate and nitrate. Allow the washings to filter through, remove the filter and precipitate to a weighed platinum crucible; cover the crucible, place on a triangle over a Bunsen burner and heat gently, not above a dull red, until the filter is completely charred. Remove the cover, incline the crucible, lay the cover so that part of it extends into the crucible and rests on the rim of the crucible and the triangle. Heat to a redness until the filter paper is burned to an ash. Remove the Bunsen burner and replace with a Bunsen blast lamp. Heat to a white heat until the precipitate is perfectly white. Set the crucible upright, put on the cover and continue the white heat for ten minutes. Remove the blast lamp, allow to cool and weigh. The difference between this weight and the weight of the crucible is the weight of magnesium pyrophosphate, which, multiplied by 0.3604, gives the weight of magnesia in 1 gram of cement. The weight of the magnesia multiplied by 100 gives the percentage of magnesia (MgO) in the cement.

THE FUNCTION OF A RAILROAD TESTING LABORATORY.

BY SAMUEL STOCKTON VOORHEES, OF THE PENNSYLVANIA RAILROAD CO.,
ALTOONA, PA.

[Read at the regular monthly meeting of the Engineers' Society of Western New York, Buffalo, N. Y., May 6, 1895.]

A SERIES of articles* on this subject appeared in one of the railroad journals which covers the ground so fully that a condensed paper may seem superfluous; but this abstract may prove of interest to those who have not the time to read the continued series.

To the casual observer the connection between the running of trains and chemistry may seem obscure, but a little thought will show their intimate relation.

The breaking of a rail, a tire or an axle may mean the loss of many thousands of dollars; an improper lubricant or bearing metal may mean a serious delay; an impure or corrosive water in the locomotive boiler might cause an explosion, and it certainly would result in an increased fuel consumption and cost of shop repairs; the failure of a signal lamp leads to a serious possibility, one that few railroad men care to contemplate; while an inferior or ill-adapted paint would be a constant annoyance and eyesore.

These examples cited are a few of the problems presented to the testing laboratory for solution, and it is possible to guard against such accidents, and in a measure eliminate the cause.

In a broad way, it is the province of the chemist to assist the purchasing agent in selecting such material for the company as will give the maximum efficiency of service at the minimum cost.

With this end in view, the work in the laboratory may be separated into three broad divisions: First, determining the chemical and physical characteristics of the supplies best adapted to the requirements, and covering these points by specifications; second, the routine work of examining shipments bought on these specifications, to determine whether they conform to the requirements; third, experimental work and investigations.

The specification is a vital point; indeed, it is the backbone of the entire structure, as it is the goal toward which all the investigation and experimental work tends. Consequently, before the results of the investigation can be embodied in the official form,

*"Contributions to Railroad Chemistry," by Dr. C. B. Dudley and F. N. Pease, appearing in the *Railroad and Engineering Journal*, December, 1889.

much experimental work must be done, and many practical tests made.

As an example, take the single instance of steel used for fire-box and boiler plate. Samples are sent to the laboratory from locomotives as they come into the shop for repairs, with as complete a history as possible in each case; length of time in service, mileage, character of water used and present general condition of the steel; or, in brief, if the service has been satisfactory, and how the result has been affected by peculiar conditions.

Then from chemical analysis and physical tests of each sample attempts are made to deduce what are the chemical and physical attributes which give to each its peculiar character. It is of the utmost importance to draw conclusions from a large number of widely different cases, and eliminate the variables of personal equation and special conditions as much as possible.

When the percentage of carbon, manganese, phosphorus, silicon, sulphur, etc., has been determined, that will give the tensile strength, elongation and general physical properties necessary for the material best adapted to the requirements of service, a tabulated report is sent to the purchasing agent for distribution among the manufacturers for criticism from the producer's standpoint, and from their report the specification may be modified to insure a working shape. The specifications for steel and iron used for other purposes are evolved in a similar manner.

In the case of oils used for burning and lubricating purposes the requirements are somewhat different. For illuminating oils it is of vital importance to reduce the danger from inflammable vapors to a minimum, by means of a safe fire test and the proper construction of lamps, and at the same time to insure a constant flame during our longest nights.

With lubricating oils and greases, the question involved is largely efficient service at minimum cost. In a suitable machine, tests are made to determine the coefficient of friction with different lubricants at varying speeds, temperatures and pressures, and at the same time the wear of both axle and bearing metal per unit of revolution; these tests, together with the practical tests in service, give a means of determining the value of a lubricant. The petroleum industry is producing such an endless variety of oils, with such different properties, that the field for the expensive fat oil is growing more and more limited, and the chemist is constantly attempting to substitute mineral oils for the latter with safety and economy.

It is hardly appreciated that the cost of paint on a large rail-

road amounts to hundreds of thousands of dollars each year, and a decrease of a fraction of a cent per pound means a considerable saving to the company.

If this can be accomplished with an increased durability of the paint, and consequently a longer life to the structure protected, the economy is large. At the same time, a standard shade and uniform color of the paint will undoubtedly improve the general appearance of the rolling stock.

While speaking of paints, it will not be out of place to mention the influence of detergents on painted or varnished surfaces; nearly all the soaps on the market contain, besides the alkali combined with the fat,—viz, the soap,—varying amounts of free alkali in the form of caustic soda and carbonate of soda, and those two act very energetically on the oils and gums in the paint or varnish.

Indeed, if the percentage of the free alkali is considerable, it often will be necessary to send the car to the paint shop after a single washing.

Enforcing the requirements for a neutral soap will reduce this trouble to a minimum.

At the same time, an analysis of the soap will enable the company to pay actually for the amount it buys.

When the soap is first made it contains considerable water, and is technically termed "green," and a pound bar of such soap will actually contain far less than a pound of dehydrated soap.

If a bar is taken from a shipment at random, weighed and the percentage of alkali, or soap, determined, it is simple to calculate the amount of soap in the shipment, and pay for that amount.

The examination of waters on the companies' lines demands considerable attention from the chemist.

An analysis will usually determine its fitness for boiler purposes, or as a potable water, and the evil, if found, can be either eliminated entirely by using another source of supply or corrected by neutralizing the corrosive action, or destroying the pathogenic germs.

It is scarcely necessary to enumerate more instances in the long list of supplies needed on a railroad. From the few examples cited it can be seen how the same system may be extended to embrace other cases.

In the sharp competition and low prices of to-day there is a constant tendency on the part of the manufacturer to work to the lower limits of the specifications and even fall below the requirements, so it is quite necessary to examine the shipments day by

day, and it is surprising to see how soon the manufacturer notes this fact and acts accordingly.

The experimental work and investigation includes the examination of many worthless nostrums, and also some valuable products where often a chemical analysis will determine the merits of the case without the expensive trial of a service test. Then, too, a substance is submitted for trial which no doubt justifies the claims made, but the cost of the ingredients and of manufacture are out of all proportion to the price charged, or an old rogue is disguised with a new name and complexion, and cast loose upon an unsuspecting public; in either case an examination will detect the fraud.

Besides this work of a purely chemical or physical character, there are certain classes of supplies, as disinfectant, polishing paste, rouge, lacquer, battery solution, zapon, etc., that can be made more economically and better adapted to the requirements in the laboratory than they can be purchased.

Indeed, the scope of a laboratory is so varied and extended, and so much of a field remains unexplored, that one can well quote from Professor Greville Williams, when one thinks of the advance which has been made, and the possibilities in the future. "The impossible is a horizon which recedes as we advance; the *terra incognita* of to-day is boldly marked on the chart of to-morrow."

DISCUSSION.

T. GUILFORD SMITH.—From a manufacturer's standpoint, I question the advisability of drawing up specifications too fully and would cite the case of steel rails. In one case the railroad's specifications even stated the method of making them.

The Erie Railroad has had such a laboratory here.

The Pennsylvania Railroad makes exhaustive tests of everything purchased, and it is the means of saving them large sums of money, as was the case when they changed the color of their cars. Their specifications are very strict, but are not unreasonable.

C. E. MANN.—I should think such a laboratory would be a good thing for the smaller roads centering here.

ASSOCIATION OF ENGINEERING SOCIETIES.

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PROCEEDINGS.

Engineers' Club of St. Louis.

MEMORIAL MEETING IN HONOR OF COL. HENRY FLAD,
SEPTEMBER 21, 1898.

WHEN the meeting was called to order, the President, Mr. Wm. H. Bryan, addressed the Club as follows:

The engineer who confines himself to the legitimate practice of his profession rarely accumulates wealth; very few monuments are erected to his memory; it is not often that he becomes famous. What then is his reward? To what may you and I and every engineer look forward?

But, after all, the engineer's rewards are not as intangible as might at first sight appear. His riches lie in the consciousness of duties well performed, of obstacles and difficulties met and overcome, and of the forces of nature conserved to the greatest benefit of mankind. His monument is not the granite column, but the steel arch, the ponderous engine. His fame comes in the esteem of his brother engineers, and of the discerning few who know what engineering triumphs mean.

The Engineers' Club of St. Louis does itself honor in setting aside an evening to the memory of Henry Flad, its first President, and for twelve years the occupant of the chair. He may truly be termed the father of the Club, and we, his children, do well to honor him. Held in the highest esteem, both at home and abroad, occupying the topmost standing in his profession, he rounded out a career which may at once be the admiration and envy of every engineer. Progressive, yet conservative in his work, and with always a smile and a word of encouragement for the young engineer, one had but to know him to esteem and revere him.

But what Henry Flad did for this Club, and what he did for the busy world in which he moved—how, and when, and where he did it—can better be told you by those whose fortune it was to know him more intimately than I did. I therefore ask Mr. Robert Moore to address you.

MR. MOORE.—When a man of the exceptional ability and high character of Henry Flad passes away, his friends and associates may well pause long enough to gather up their memories of the man and of his works, and to put on record their tribute to his worth, for nothing can be more instruc-

tive or inspiring than the life of such a man, and no act more worthy of themselves than to pay their debt of recognition to his noble qualities. And for one who, like myself, has by years of association come to know his great ability and to revere the single-minded unselfishness and fidelity of the man, no task can be more welcome than the opportunity to add my word to your tribute to his memory.

Henry Flad was one of many men of rare ability for whose presence in America we are indebted to the Republican Revolution of 1848-49 in Germany. He was born July 30, 1824, in the Grand Duchy of Baden, near the university town of Heidelberg. His father, Jacob Flad, dying within the same year, his mother, Francisca Brunn Flad, very soon afterwards removed to the town of Speyer, a few miles distant upon the left bank of the Rhine in the Rhine Palatinate, a province belonging to Bavaria. After passing through the preparatory schools of Speyer, young Henry entered the University of Munich, in Bavaria, where he took the polytechnic course.

After his graduation, in 1846, at twenty-two years of age, he was given a position in the engineering service of the Bavarian Government, his first employment being on works for the improvement of the River Rhine. The years which immediately followed, particularly the years 1848 and 1849, were years of great political commotion throughout Europe. Encouraged by the success of the revolution in France which drove out King Louis Philippe, the longings of the German people for a freer and more united government found such vigorous expression that the princes of the many petty states into which Germany was divided acceded to the convocation of a National Assembly or Parliament which, in May, 1848, met in Frankfurt to frame a constitution for United Germany. Unfortunately the deliberations of this assembly showed such wide differences of opinion and so little ability to unite in any workable plan that the ardor of the more conservative classes began to cool. The princes seized their opportunity to reassert themselves and repudiated the authority of the Parliament.

In Southern Germany the champions of the Parliament took up arms in its behalf. Amongst them was Henry Flad, then in his twenty-fifth year, who joined the Parliamentary army as a captain of engineers. Fortune, however, was against them, and after several engagements the Parliamentary army was driven into Switzerland and disbanded. Meantime its leaders were placed under the ban, and Captain Flad, with many others, was sentenced to death.

Under these circumstances he very naturally turned his face westward and took passage for the United States, where the right of the people to govern themselves has found its fullest expression. He landed in New York in the autumn of 1849.

His first employment after his landing was as a draftsman in an architect's office. It was not long, however, before he entered the engineering service of the New York and Erie Railroad, then under construction, his headquarters being at Dunkirk, at the extreme western end of the road. Mr. James P. Kirkwood and Mr. James H. Morley, with whom Captain Flad was afterwards associated, were also employed at this time on the same road. After the completion of the New York and Erie Railroad, in 1851, we hear of Captain Flad first as located for a time at Tonawanda, between Niagara Falls and Buffalo, and then, in 1852, as an assistant engineer in the

construction of the Ohio and Mississippi Railroad from Cincinnati to St. Louis, his headquarters being at Vincennes, Ind.

Upon the opening of the Ohio and Mississippi Railroad to St. Louis, in 1854,—this being the first railway to reach St. Louis from the East,—Captain Flad went to Missouri as an assistant engineer on the Iron Mountain Railroad, of which his former colleague on the Erie Railroad, Mr. James H. Morley, was the chief engineer. During the construction of this road Captain Flad was located at Potosi, Missouri. After its completion to Pilot Knob, where for a number of years it ended, he became land and tie agent of the railroad company, with headquarters at Arcadia, Missouri. During this period, viz., on September 12, 1856, Captain Flad was married to Miss Reichard, of St. Louis.

Upon the outbreak of the Civil War, in 1861, Captain Flad came to St. Louis and enlisted, June 15, as a private soldier in Company F, of the Third Regiment, United States Reserve Corps. From this rank he rose rapidly, advanced to be corporal and then sergeant.

In July, 1861, a regiment known as the Engineer Regiment of the West, recruited mainly in the States of Illinois and Missouri, was organized by Col. J. W. Bissell, and Henry Flad was made captain of Company B. In August of the same year he was detailed by General Fremont, then in command at St. Louis, for service in the construction of fortifications at Cape Girardeau, Mo., where he remained for several months. Later in the year, when Fremont was succeeded by General Halleck, Captain Flad was ordered to join General Pope in southeast Missouri, and served as a staff officer through the campaign of New Madrid and Point Pleasant and the taking of Island Number Ten, after which he rejoined his regiment at New Madrid. He was with his regiment at Fort Pillow and Pittsburg Landing, and in the operations before Corinth. During the summer of 1862 he was engaged in repairing the Mobile and Ohio Railroad, in building forts at Corinth, and in repairing the Mississippi Central Railroad. He was also engaged in Grant's advance on Grenada. In February, 1863, he was ordered to Young's Point, where he was employed in engineering work, as he was later at Baxter Bayou, Lake Providence and Bayou Macon.

In April, 1863, he had charge of the repairs of the Memphis and Charleston Railroad at Memphis, Grand Junction, Jackson and Columbus. In October of the same year he was employed in repairing the same railroad east of Corinth, under General Sherman, and was with him at Cherokee, Bear Creek and Iuka in northern Mississippi.

Meantime he had been promoted, November 17, 1862, to the rank of Major, July 30, 1863, to that of Lieutenant-Colonel, and October 16, 1863, to that of Colonel. On January 1, 1864, at Nashville, Tenn., he was transferred, as Colonel, to the First Regiment of Engineers, Missouri Volunteers, a new regiment formed by the consolidation of the former engineer regiment and the Twenty-fifth Missouri Infantry. During the summer of 1864 he was engaged in completing the Nashville and Northwestern Railroad from Nashville to Johnsonville, and in constructing defensive works. In August he was ordered to Atlanta and served here and in this neighborhood until about the first of November, his last work being the construction of a new line of fortifications at Atlanta.

At this time the term of enlistment of seven companies expired. The command of the remaining five companies then, under the army regulations, devolved upon the Lieutenant-Colonel, and the Colonel was mustered out

November 12, 1864, at Nashville, Tenn. His term of service had been three years and six months, during which time, with not more than a week's leave of absence, he had been constantly in the field. Through it all he was never sick, wounded or captured.

Upon being mustered out, Colonel Flad returned to St. Louis, and began to look around for employment in his profession. In a short time the agitation for an improved water supply for St. Louis took form in a State law authorizing the appointment of a Board of Water Commissioners, charged with the duty of making surveys and plans and constructing a new system of waterworks for the city. Soon after the organization of the new board, in the spring of 1865, Mr. James P. Kirkwood, who had formerly been chief engineer of the Pacific (now the Missouri Pacific) Railroad, and had just completed the building of new waterworks for Brooklyn, N. Y., was appointed chief engineer, and Henry Flad, chief assistant engineer.

Surveys and investigations were at once begun, and, by the end of the year, a plan was presented for new works with intake, settling basins and filter beds at the Chain of Rocks, and a distributing reservoir on what was then known as Rinkels Hill, on Easton avenue, near the present city limits. This plan received the approval of the Board of Water Commissioners, and, as subsequent experience has abundantly proven, was undoubtedly the best. But, besides running counter to some private interests, it involved such a large outlay and such a radical departure from the old plan that on the part of many leading citizens as well as the city authorities it encountered an overwhelming disapproval. The opposition finally became so great that the Water Commissioners were called upon by the City Council to resign. To this demand they presently acceded, and, in July, 1866, a new board, committed to a new plan, was appointed. Meantime Mr. Kirkwood had been commissioned to go to Europe to study the subject of filtration, and Colonel Flad was left as acting chief engineer. In December, 1866, a revised plan, with intake and settling basins at Bissel's Point and a distributing reservoir on Compton Hill, substantially as afterwards built, was presented.

Early in the following year the act organizing the Board of Water Commissioners was amended, the number of members being reduced from four to three, and in March, 1867, a new board was appointed with Colonel Flad as one of its members. This position by reappointment he held continuously for eight years, or until April, 1875. During this time, and under his general supervision, the new waterworks were completed and put into service during the year 1872.

Whilst he was still acting as assistant engineer to Mr. Kirkwood, Colonel Flad made the acquaintance of Captain James B. Eads, who was at that time employed upon plans for gun carriages and turrets. The rooms occupied by the Water Board being larger than they then needed, Captain Eads, upon his request, had been granted space in which to set a draftsman at work. This was followed by frequent discussions between the two men upon engineering questions, and this led to a mutual recognition of each other's abilities and laid the foundation of a life-long friendship. When, therefore, in 1868, Captain Eads was ready, as chief promoter as well as chief engineer, to begin the work of constructing the great bridge over the Mississippi River at St. Louis he very naturally tendered the position of chief assistant engineer to Colonel Flad. As the duties of the latter,

as member of the Board of Water Commissioners, did not require all his time, this opportunity to take part in this most interesting and important work was gladly accepted, and he retained his connection with it until its completion in 1874. Some of the boldest features of this great enterprise, such as the method of erection without false work, were due to Colonel Flad.

During 1875 and 1876 he was engaged as consulting engineer in various works in conjunction with Mr. Charles Pfeiffer, who had been associated with him on the St. Louis bridge; Mr. Thos. J. Whitman, chief engineer of the Waterworks, and Prof. Chas. A. Smith, of Washington University. Amongst other engagements he was engineer for the commissioners who purchased and laid out Forest Park.

In the autumn of 1876 the new charter of the city of St. Louis, by virtue of which the city was separated from the county of St. Louis and made, as to its local affairs, to a large degree independent of the State Legislature, was inaugurated, and Colonel Flad was elected the first President of the newly constituted Board of Public Improvements. This office he held continuously for nearly fourteen years, being re-elected in 1880, 1884 and 1888.

The problem to which the new board addressed itself was that of taking the whole system of municipal public works out of the mire of politics and placing them upon the basis of merit and fitness. Into this work Colonel Flad entered with characteristic zeal and a determination which nothing could shake. His efforts were crowned with entire success, so that during the whole period of his administration the board over which he presided had the entire confidence of the whole community. Every citizen felt sure that in every department of the public works the city received a dollar's worth for every dollar spent, and in this respect St. Louis became a model for other cities.

In the spring of 1890, having become somewhat weary under the increasing burdens of his position, he resigned his office as President of the Board of Public Improvements to accept membership in the Mississippi River Commission in the place made vacant by the resignation of Captain Eads. In this latter position he remained until his death, giving to the work his best energies and nearly the whole of his time. The new policy of deepening the low water channel of the river by dredging rather than by contraction works, which the commission adopted during his membership, was very largely the result of his efforts.

Colonel Flad was a charter member of the Engineers' Club of St. Louis, and was its President for twelve years, from 1868 to 1880. He became a member of the American Society of Civil Engineers February 15, 1871, and was President of the Society for the year ending January 19, 1887, thus receiving from both organizations the highest honors within their power to bestow.

His death occurred June 20, 1898, at Pittsburg, Pa., where he stopped on his way home from a meeting of the Mississippi River Commission to visit Mr. Godfrey Stengel, a life-long friend who had come with him on the same ship to America forty-nine years before. He died very suddenly of acute heart failure whilst walking home from one of the parks in company with Mr. and Mrs. Stengel. Up to the last moment he was in excellent spirits and died without pain as without fear.

As an engineer Colonel Flad was remarkable for his great fertility of

invention. For every new problem he had not only one but many solutions, and the rapidity with which he grasped all its conditions and framed his plans to meet them amounted to genius. In doing this he was not limited by precedent, but looked instinctively for new and better methods than any before known. In boldness and originality he has had but few equals in the annals of the profession. And, like the most successful workers in every field, he delighted in his work for its own sake. Nothing could exceed the interest with which he attacked a new problem, and he gave himself no rest until he had solved it. The solution once found, however, the whole subject ceased to interest him, and he passed on to something new. This trait is illustrated by the fact that, although he took out numerous patents for new and useful inventions, to their introduction and utilization he gave no thought. It was the work, rather than its rewards, for which he cared.

As a man, he was equally great. His unassuming modesty, his perfect candor and simplicity, his unflinching courage, his absolute fidelity to his convictions, his single-minded subordination of personal to the public welfare,—qualities which were written in every line of his face and manifested in every act of his life,—all stamped him as a man of the highest type. No one who knew him but believed in him without limit. His name was a synonym for fidelity and skill, and all knew that every work committed to his charge would be well done and come from his hand as sound and flawless as the man himself.

This evident and perfect integrity of purpose made his public service a legacy of incalculable value to his fellow-citizens. His life was a demonstration of how honorable the public service could be made, and is an encouragement to those who have not yet lost faith in the possibility of having this service in all its branches lifted to the same standard to "abate no jot of heart or hope," but still work on for the accomplishment of this high end.

To us, his fellows in his chosen calling, his name and example are specially precious. For in him was realized the highest ideal of the engineer,—a man of trained intellect, controlled by an iron will, and directed to the noblest public ends. And the fact of his success in attaining this ideal will inspire others to frame their lives upon the same noble lines.

DR. WOODWARD.—Mr. President and Gentlemen, I had supposed that Mr. Pitzman would follow Mr. Moore, but I am very glad to say a word at this point, or at any point, when the name of Henry Flad is before us. I felt, as I looked out into the storm to-night, that on any other occasion I could easily have stayed at home, but under no consideration would I be willing to be away when I was invited to come to a memorial meeting in honor of Henry Flad.

I have known Henry Flad a long while; and I have in part, I think, appreciated his high character and his great skill. I appreciate the exact justice with which Mr. Moore has treated him, how he has seen clearly into his intellectual, moral and social nature, and I indorse it all, every bit of it.

I came to this city in 1865, just when Colonel Flad was freed from his military duties and had begun work really in the city of St. Louis. The story that has been told you shows that from 1865 to 1898, almost continually from 1865 until 1880, Colonel Flad gave his undivided attention to the interests of this city, including, of course, the construction of the bridge.

Then I was quite a young man, in 1865,—I did not consider myself an

engineer at all; I was hardly, in fact, in touch with the engineering profession; but I had not been in St. Louis long before I began to feel the attraction of that society which clustered around the first Board of Water Commissioners, one of whom was Colonel Flad, another Mr. Whitman. There were Mr. Davis and a few others, among them Colonel Mysenberg, who always sat around the table in the old Water Commissioners' Office. And all of us felt Colonel Flad was the main man; as Mr. Moore has said, he was the father, and the others, as it were, his children. Mr. Kirkwood was not there; I did not have the honor or pleasure of his acquaintance.

But from that time to the day of his death Colonel Flad was my friend, and I drew inspiration from his lips and from his example. The problems of the bridge, the problems of the waterworks, were of unfailing interest in those days, and it was there that I became personally interested in the bridge and in all that related to it.

There was one thing about Colonel Flad that inspired the admiration of all, and that was his absolute intellectual and moral honesty. He was honest toward everybody and thoroughly honest with himself. It was impossible for him to deceive anyone, and it was equally impossible for him to deceive himself. That is a characteristic which is not fully appreciated, but I think that he possessed it, and he stood as a tower of strength and a splendid example to the young engineers who are growing up in this city. It has been my fortune to have something to do with the training of a large number of engineers, and I think that no one man's life has had more to do with their general high character than the constant example of Henry Flad.

His friendships were largely inspired by intellectual and professional sympathy. It was impossible for him to be associated with a good engineer without being that engineer's friend, his warm friend.

Mr. Moore has told you about Colonel Flad as a soldier. I can think of him only as an engineer and as a man. As a soldier he must have been good as he was as an engineer.

I remember one trying month, or rather a part of a month, when they were sinking the first caisson under the east pier of the St. Louis Bridge. I was deeply interested in watching the bridge from the beginning to the end of its construction; Colonel Flad, Mr. Pfeifer and Colonel Roberts divided the twenty-four hours of the day between them, each serving eight hours, taking charge of the work of sinking the first caisson until it rested firmly and safely upon the sand. During that portion of the work, during the storm and rush of water, everything was of the deepest interest. Of those men each kept a log which recorded everything that was done and their experience, as a warning to the next man who followed, and no man left the work until his successor was in place to relieve him. I have read that log through a great many times, as I have read everything Colonel Flad left in connection with his work on the bridge; and you can readily understand how, as I followed his personal experiences, I read his thoughts and shared with him the anxiety that he felt, and the anxiety that the other engineers felt while that work was going on.

He was a man of undaunted courage. He had the courage of his convictions, whether the question was one of engineering or one of municipal policy or whatever it was. He was never found wanting.

Mr. Bryan says we do not build high monuments to engineers. But his monument stands. He has a large share in the St. Louis Bridge, how large a share no man can tell. He never was jealous of other engineers,

he never was eager to claim priority of thought or device; and how fully his suggestions entered into that steel arch, and how fully "Henry Flad" was written all over it in imperishable characters, no one can exactly tell. Captain Eads and Mr. Pfeifer and two or three other men were in constant intercourse. They were men who were willing to take and able to give.

I remember a story told during the war of a man who had been employed previous to his enlistment as a maker of locomotives. On one occasion in the early days of the war his regiment was halted in the presence of a disabled engine between Annapolis and Washington. The Colonel marched down the line and said: "Is there any man here who knows how to repair a locomotive, and put it in shape?" One man stepped out and said: "I know something about locomotives." He went into the engine house and found what you would call an old rattletrap of a locomotive, but his name was written all over it. He had had a share in the building of that locomotive and he was very quick to assist in putting it in order again. Now that was, in a certain sense, his monument. Colonel Flad's monument lies all around this city. Every cup of water we drink, every comfort we enjoy, the comfort we take in our well-built streets—so far as they go—and in many other schemes of municipal improvement, we notice the monument of Henry Flad, and I feel it due to him and to this Club, to the engineering profession, that the young men coming after us know that.

I am glad that Henry Flad's picture will always hang in the rooms of the Engineers' Club, glad that the young men studying engineering may realize how grand a profession it can be in the hands of a master like Henry Flad. There is something greater than merely the accumulation of wealth; men may accumulate a glory that hangs around them as it hangs to-night and always will hang around the name of Henry Flad.

JULIUS FITZMAN.—I appreciate the feeling which prompted our colleague, Mr. Moore, to eulogize our departed friend, Henry Flad, because his association with him in the Board of Public Improvements has enabled him to study his character and to measure his ability. I believe that all those of you gentlemen who have known Colonel Flad intimately will agree with me when I say that he was one of the few men of high position who constantly grew in your estimation on close acquaintance.

That love of liberty which filled the hearts of the young students of the German Universities swept over the country and caused the revolution of 1848, brought him, with many other bright and enthusiastic young republicans, to our shores, to enjoy here that freedom for the attainment of which, in Germany, they had risked their lives.

Colonel Flad had great advantages over most of his friends who came with him, for the reason that in the United States engineers of scientific attainment and practical knowledge were few and far between; and, possessing those qualifications, he was enabled to procure positions in which he could display his ability and advance in his profession by the practical application of his theoretical knowledge. My acquaintance with him dates back to about 1856, when he was the engineer in charge of construction of some of the most difficult portions of the Iron Mountain Railroad. During the time he was in the employment of that road he occasionally came to St. Louis, and it was always a great pleasure to his friends to meet him and to learn from him the manner in which he overcame the difficulties he encountered.

Just as soon as war was declared, he, like all those who had fought in

Germany on the revolutionary side, volunteered at once, and responded to the call of the President, entered as a private in the Third Regiment of Missouri Volunteers; was very soon advanced to corporal, then to sergeant, and, when General Fremont came to take charge of the Army of the West, he was appointed Captain of Engineers. Subsequently the Engineer Regiment of the West was organized under command of Colonel Bissell, and, as Mr. Moore has stated, in June, 1862, Henry Flad was elected captain of one of the companies. When this regiment was ordered to the front, it was soon discovered that it, like the majority of volunteer regiments, had elected officers who were not qualified to discharge the duties required of them. Then the weeding-out process commenced. In consequence of this Captain Flad was steadily advanced. He was first placed in command of a battalion, subsequently advanced to the position of lieutenant-colonel, and in October, 1863, he was made colonel of the regiment.

Notwithstanding that his regiment did very little fighting, it rendered the most valuable service. As the Army of the Tennessee, to which his regiment was attached, advanced, nearly all the bridges on the highways as well as on the railroads, were destroyed, and, to prevent a delay in advancing the army, a part of his regiment was kept near the front in charge of the pontoons, to enable us to cross the rivers and sloughs without delay. The large body of the regiment was generally kept in the rear to rebuild railroad bridges and to repair the roadbed so as to keep open the communication with our base of supplies.

You can easily imagine the great value of the service rendered by his regiment, when you take into consideration that General Grant had about 100,000 men in his commands and operating hundreds of miles south of its base. The reports you gentlemen have heard from Santiago, where we had to supply only 25,000 men, ten or fifteen miles from the landing, and where we appeared to have encountered great difficulties in supplying that small force with ammunition and with the necessities of life, must convince you of the difficulties of supplying an army advancing as rapidly as Grant's army did in those campaigns, and you can readily understand the importance of the services rendered by such a regiment.

On several occasions, in my presence, Generals Grant and Sherman spoke in the highest terms of Colonel Flad and of the efficiency of the regiment under his command, and they could always rely upon his reports as to the time when a line of communication could be opened.

Mr. Moore and Dr. Woodward have given you a full statement of the work done by Colonel Flad after his return to St. Louis, when the time for which his regiment enlisted had expired, but I feel it to be my duty to call your special attention to the very important service he has rendered by accepting the Presidency of the Board of Public Improvements. The reputation for ability and unquestionable integrity which the Board of Public Improvements has enjoyed, and does still enjoy, is attributable to him more than to any other individual member of the board, and it was due to his influence that the best results were obtained by perfect harmony between the heads of departments and by close attention to the intelligent discharge of his duties. The reconstruction of the streets in the central part of the city was carried into effect against the combined influence of nearly all the real estate owners, and of the landed aristocracy of St. Louis, and this victory was not due to political influence, but it was achieved by the moral

weight which the Board of Public Improvements exercised, and by the faith the public had in the honesty and integrity of the Board.

Colonel Flad's sudden death has prevented him from completing his plans for the improvement of the Mississippi River, and has deprived us of the most honored and revered member of our profession, and I hope that the shining example he has set may exercise a beneficial influence upon the members of our profession.

We hardly appreciate the difficulties Colonel Flad encountered at the time he was elected to the Presidency of the Board of Public Improvements. St. Louis was at that time in the county of St. Louis and was governed under the provisions of the statutes of the State. The separation under the provisions of the scheme and charter created an independent corporate body of St. Louis, and it required the drafting of appropriate ordinances and the inauguration of an entire new system for the government of the city and the management of its affairs. In this difficult position Colonel Flad proved himself to be the right man in the right place, and he, with the assistance of his associates, has inaugurated a system of government which, for the time being, has proved a great success.

I don't know that the German Government has imposed the death penalty upon any of the revolutionists except upon a few who were captured at the time. In later years general amnesty was granted, but very few who had emigrated to the United States ever returned to avail themselves of it. Carl Shurz, who was one of the revolutionists and who took a very prominent part, visited Germany some fifteen years ago, and he was not shot, but instead was invited to dine with Prince Bismarck, and he was well received by Government officials.

MR. MOORE.—They were not in the jurisdiction.

MR. PITZMAN.—In 1848 the revolutionary element in Berlin had absolute control of the city, and when those that were killed by the soldiers were buried, the King was made to come to the balcony and take off his hat until the entire procession had passed. There was, however, a total lack of organization and the glory lasted only a few weeks. The troops from those portions of the kingdom which were not affected by the revolutionary spirit were brought to Berlin and to the other cities which had revolted, and the despotism was very soon re-established and persecutions commenced.

PROF. J. B. JOHNSON.—To all who knew him professionally, the life and work of Col. Henry Flad will serve as a perpetual stimulus to noble endeavor. In him were united the three essentials of a great engineer,—native genius, technical training, and moral character. He had the faculty of seeing things in their relations of cause and effect, and could vigorously calculate the proportionate influences of each of many conspiring agencies. In devising means to ends he was marvelously ingenious, and never hesitated to follow his plans in the working out of new problems. He was absolutely honest in thought, word and deed, both to himself and to others. By no possibility could he have led himself, by any kind of specious or sophistical reasoning, to an oblique view of any moral question. The rightness or wrongness of any act was by him so clearly perceived that he could not be led into any kind of compromising situation. Although more severe with himself than in his judgment of others, yet whenever he had lost confidence in the integrity of any man, he had no future use for him and could with difficulty conceal his dislike for him. He was particularly

impatient with what he might consider professional or scientific untruth, whether indulged in ignorantly or knowingly, and his enthusiasm for the scientifically true and for the morally right may sometimes have led him into uncharitable judgment of the acts of other people.

The void left by the death of a great man can never be filled, for he had an individuality all his own which cannot be duplicated. So we feel that in the death of Colonel Flad a vacancy has been created in the ranks of the engineering profession which cannot be supplied. His memory, however, shall ever be treasured by his contemporaries as a high ideal to which they may aspire and by which they may with profit compare themselves; and his shining example of what an engineer may, and should be, will shed its benignant light upon many future generations of engineers.

482D MEETING, JANUARY 4, 1899.—The meeting was held at 1600 Lucas Place, at 8 P.M., with President Colby in the chair. Twenty-four members and four visitors were present. The minutes of the 480th and 481st meetings of the Club and the 266th and 267th meetings of the Executive Committee were read and approved.

The Secretary announced that he had received an application for membership from Mr. Louis Ruckert. The application for membership of Mr. Wm. F. Scott having been favorably reported upon by the Executive Committee, this gentleman was balloted for and elected a member of the Club.

The President stated that as no one had been chosen for the office of Vice-President on the latter ballot, he would declare the office vacant, and call for nominations.

The Chair stated that he would rule that all those who had been nominated for Vice-President at the 480th meeting were still in nomination.

An appeal was taken from this ruling, and, on being put to a vote, was carried.

The following nominations were then made for Vice-President:

E. J. Spencer, E. A. Herman, F. E. Nipher and M. L. Holman. On the first ballot there was no election, as none of the candidates received a majority of the votes cast. On motion, the name of the candidate receiving the lowest number of votes was dropped and a new ballot taken. On this ballot F. E. Nipher was elected.

The Secretary announced that during the year 1898 resignations had been received from the following members: N. W. Eayrs, W. K. Hatt, Wm. H. Boehn, A. B. Man, E. W. Stern and H. M. Chittenden.

The Secretary read a communication from the Association of Engineers of Virginia, announcing that the organization had disbanded.

The paper of the evening, by Mr. S. E. Freeman, was then read. It was entitled "Steel Forgings, Solid and Hollow." The paper described the practice at the Bethlehem Iron Works in making steel forgings, and discussed the advantages of hollow over solid castings. A large number of lantern slides were exhibited, showing the processes of making large steel forgings.

The discussion following this paper was participated in by Mr. Borden and Professor Johnson.

There being no further business, the meeting adjourned.

RICHARD McCULLOCH, *Secretary pro tem.*

483D MEETING, JANUARY 18, 1899.—The meeting was held at 1600 Lucas Place at 8.15 P.M.; President Colby in the chair. Thirty-one members and ten visitors were present. The minutes of the 482d meeting were read and approved. The minutes of the 268th meeting of the Executive Committee were read. The application of Mr. Louis Ruckert having been approved by the Executive Committee, he was balloted for and declared elected a member of the Club. The application of Mr. H. S. Wilson for membership was announced.

Mr. J. A. Ockerson then read the paper of the evening, entitled "The Southwest Pass of the Mississippi River." The paper described fully the methods of the last survey, and the physical characteristics of the pass, mentioning especially the character of the banks and the peculiar mud lumps which form at various points. The several openings from the pass to the gulf were mentioned and their dimensions given. Methods used in making soundings, both in the pass and in the gulf at its mouth, were fully explained, so the accuracy of the survey was apparent. The slope of the river in the pass was stated and the effect of the winds and tides on the slope discussed. The movement of the crest of the bar at the mouth of the pass was described as shown by the surveys of different periods, and the conditions affecting the rate of advance discussed. The advance is due mainly to the rolling of the sand up the rear and down the front of the bar. The most of the silt brought down by the river is deposited before reaching the bar and goes to building up the banks. Where the river divides into the several passes, the discharges of each pass were measured daily, and the discharges of each given in percentages of the total discharge of the river. The plans of the Board of Engineers appointed to report on the improvement of the S. W. pass were set forth, and the nature of the jetties which they proposed was described; also the necessity for the improvement of this pass was discussed. Drawings and photos were exhibited showing the various points. The discussion following was participated in by Messrs. Flad, Connor, Freeman, Bouton, Colby, Herman, Russell and Turner.

The President called attention of the Club to the forthcoming bulletin and its advantages for advertising.

An Entertainment Committee for 1899, consisting of Messrs. Wall, Zeller and Dunaway, was appointed. On motion of Mr. Bryan, a committee to draft resolutions on the death of Mr. Winthrop Bartlett was appointed. Mr. M. L. Holman was named as chairman and authorized to select his two associates. There being no further business, the meeting adjourned to another room, where lunch was served.

E. R. FISH, *Secretary*.

James Francis.—A Memoir.

BY ARTHUR T. SAFFORD AND WALDO E. BUCK, COMMITTEE OF THE
BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, January 25, 1899.]

THE death of James Francis, on December 1, 1898, a little over six years after the death of his father, James B. Francis, removes the second representative of that name which has been so closely identified with the history of Lowell, Massachusetts.

James Francis, or, as he was so generally known, Colonel Francis, was

born in Lowell, Mass., March 30, 1840. His early education was obtained in the public schools of Lowell; later his instruction was private. In his twentieth year he entered the Lowell Machine Shop as an apprentice, studying and working in the different departments until the breaking out of the Civil War, when, at the first call to arms, he enlisted, with a number of the younger men in the Lowell Machine Shop, in Company A, of the Second Massachusetts Regiment. He served throughout the war. A brief account of his services, from an obituary in one of the Lowell newspapers, says: "He was under General Patterson in the Shenandoah Valley, with Banks in his retreat, with the Army of the Potomac in the winter of 1862-3, and participated in the battles of Cedar Mountain, Chancellorsville, Antietam and Gettysburg. He was afterwards in the corps sent to quell the draft riots in New York. He then served in the West and along the line of the Chattanooga Railroad; was with Sherman in his march to the sea, and participated in all the engagements during that march. He was wounded in the battle of Antietam.

"Mr. Francis received the following commissions: Second Lieutenant, May 25, 1861; First Lieutenant, November, 1861; Captain, August 10, 1862; Major, July 4, 1863; Brevet Lieutenant-Colonel, March 13, 1865, for distinguished gallantry in Georgia and the Carolinas. He was commissioned Lieutenant-Colonel July 24, 1865."

After being honorably discharged, in August, 1865, he became associated with the engineering work at Hoosac Tunnel as an assistant. He came back to Lowell in 1866, becoming, in April of the next year, first assistant engineer of the Locks and Canals. On January 1, 1885, he succeeded his father, James B. Francis, as agent and engineer of the Locks and Canals, and remained in charge of the different interests of this company until 1894. From that time until his death he was agent of the same company, having charge of the rents, real estate and system of fire protection.

Although Colonel Francis had been failing rapidly for the two months previous to his last sickness his death was a great shock to all those associated with him. Previous to the last years he seemed to have borne almost a charmed life. Mention has been made of his being wounded at Antietam. It was a flesh wound through the hand; otherwise he came out of the war unscathed.

It is remarkable that he should have braved the dangers of the war to meet with his greatest accidents in the pursuit of his profession. In 1888, during the construction of the wall of the Pawtucket Canal, while standing on the top of the wall, he was struck by a drag box and knocked off into the canal, falling more than twenty-three feet, onto a pile of dirt and broken stone. Both of his legs were broken; each in more than one place, but, after careful treatment, excepting for a slight limp, he was able to walk with comparative ease. His recovery was looked upon as almost miraculous. In the summer preceding his death he was thrown from his carriage to the ground without any chance to break the fall. To a man of his age and weight, the shock was particularly severe and doubtless aggravated the conditions which caused his death. He never fully recovered from this accident, but steadily lost strength until he passed quietly away without suffering of any kind.

His engineering work has always been so intimately associated with carrying out the plans of his father, James B. Francis, that it is difficult to say just how much of originality Colonel Francis exercised in his work.

He certainly was not radical in his methods or ideas; he believed himself warranted in following the path laid out by the elder Francis, so successful had the latter been in the management of the water power and land of the Locks and Canals.

There are two things which are particularly characteristic of Colonel Francis in all his relations to his engineering work and associates and to his fellow-men,—his great-heartedness and his absolute honesty of thought and purpose. His work was done entirely for the sake of its use in the world and not for his own advancement.

One had to be brought into intimate contact with Mr. Francis to know his character. Few, if any, heard from Colonel Francis himself of anything that he did in the war; but the soldiers of his command have told of repeated occasions when Colonel Francis would spend the time, after one of the great battles, searching for the wounded to minister to them; and the lives of several men were saved, through his own personal efforts, to bear witness to his unselfishness. Among the poor and unfortunate Colonel Francis has been generous to a fault, and many a one will miss his ready sympathy and open purse.

His absolute honesty of thought and purpose was shown in his relations to the mill corporations whose agent he was. The rights of each, as laid down in their indentures, were almost religiously observed; and there was no attempt to cater to the great corporations and disregard the rights of the small ones. Absolute impartiality was his watchword.

Probably Colonel Francis's greatest achievement, outside of the good management which characterized his work in Lowell for thirteen years, was the scheme for the regulation of the power on the Concord River at what is known as Whipple's Falls, Lowell. The different interests there had been involved in lawsuits for years; no one corporation was able to get its lawful property, and the problem was given by the court to Colonel Francis to straighten out. He designed a system for the proper regulation of the water power, and this system has been in use since June 19, 1894, to the satisfaction of every interest concerned. This was one of those involved cases which need not so much a bright engineer as a broad-minded man who strives only for justice to all.

There are some men whose lives are remembered by a series of great works accomplished, and their names invariably suggest to the mind the character of their works. This I think can be said of the elder Francis. Then there are a few, who, although working along lines laid down by others, yet add to their work such a trust in the greatness of God and the nobleness of man that they elevate this sphere of usefulness and make it resemble the divine work.

The younger Francis belonged to this latter class, and those who knew him well will remember him well. Any young man who has been brought into close contact with him would hesitate to do anything unworthy of his manhood.

Colonel Francis became a member of the Boston Society of Civil Engineers September 16, 1885, and of the American Society of Civil Engineers January 4, 1893.

He leaves a son, Joseph S. Francis, a graduate of Harvard University and a lieutenant in the First Massachusetts Heavy Artillery. He has followed the profession of his father and grandfather, being now an assistant engineer in the Philadelphia branch of the American Bell Telephone Company.

Boston Society of Civil Engineers.

BOSTON, MASS., DECEMBER 21, 1898.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M.; President Howard A. Carson in the chair; fifty-five members and visitors present. The record of the last meeting was read and approved.

Messrs. Charles W. Aiken, Harold K. Barrows, Frank H. Mills and George E. Stratton were elected members of the Society.

The President announced the death of Col. James Francis, a member of the Society, which occurred December 1, 1898. The President was authorized to appoint a committee to prepare a memoir, and since the meeting has named as members of the committee Messrs. Waldo E. Buck and Arthur T. Safford.

The first paper of the evening, entitled "Power and Equipment of Electric Railways," by Messrs. H. H. Hunt and C. K. Stearns, was then read by Mr. Hunt.

Mr. A. D. Adams discussed briefly the means which had been used to prevent electrolysis in Boston and other cities.

The thanks of the Society were voted to Messrs. Hunt and Stearns for their kindness in presenting to the Society so interesting and instructive a paper.

Prof. Jerome Sondericker read the second paper of the evening, entitled "Comparative Tests on Different Forms of Cement Briquettes." A general discussion followed on the testing of cement and forms of briquettes.

Adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., JANUARY 25, 1899.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.50 o'clock P.M.; President Howard A. Carson in the chair; ninety-three members and visitors present. The record of the last meeting was read and approved.

Messrs. Arthur B. Corthell and James C. S. Taber were elected members of the Society.

On motion of Mr. R. S. Hale, the President was requested to appoint a committee of three to report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President appointed as this committee Messrs. R. S. Hale, F. L. Fuller and H. B. Wood. Later in the evening this committee reported as members of the nominating committee Messrs. W. E. McClintock, C. T. Main, E. P. Adams, A. D. Flinn and R. A. Hale, and they were unanimously chosen by the Society.

The thanks of the Society were voted to the following gentlemen for courtesies extended to its members on the occasion of the visit to the Boston and Oxford Exchanges of the New England Telephone and Telegraph Company: Messrs. Thomas Sherwin, J. N. Keller, I. H. Farnham, C. J. H. Woodbury, G. K. Mason and F. L. Gilman.

On motion of Mr. A. H. French it was voted that the annual dinner of the Society be held on the evening of February 7, 1899, as proposed by the Board of Government, that Mr. Henry Manley be a committee of one,

with full powers, to arrange for the dinner, and that the sum of \$50 be appropriated for the incidental expenses of the same.

Mr. A. T. Safford, for the committee appointed to prepare a memoir of Col. James Francis, submitted its report, which was read and accepted.

Mr. L. M. Hastings then read the paper of the evening, entitled "Experience in Sewer Construction." The paper was discussed by Messrs. G. A. Kimball, H. D. Woods, T. H. Barnes, E. S. Dorr, A. H. French, Desmond FitzGerald and others.

Adjourned.

S. E. TINKHAM, *Secretary*.

Engineers' Club of Cincinnati.

CINCINNATI, O., JANUARY 19, 1899.—The 102d regular meeting of the Club was held in the rooms of the Literary Club, being called to order at 8.10 P.M.; President Hazard in the chair.

There were twenty members present, also twenty-five members of the Ohio Society of Surveyors and Civil Engineers and visitors.

The Ohio Society has been holding its annual convention in Cincinnati during the week and arrangements had been made to entertain its members in the shape of a joint session at this meeting.

The reading of the minutes and the transaction of routine business were dispensed with.

Hon. Martin Dodge, director of the Bureau of Road Inquiry, delivered an address on "Better Roads and the Free Delivery of Mail," and Professor L. A. Bauer, of the University of Cincinnati, read a paper on "The Magnetic and the Boundary Work of the Maryland Geological Survey."

A buffet luncheon was served after adjournment.

J. F. WILSON, *Secretary*.

Louisiana Engineering Society.

NEW ORLEANS, SATURDAY, JANUARY 14, 1899.—The annual meeting of the Louisiana Engineering Society was called to order this date at 8.20 P.M. by President S. F. Lewis, with seventeen members and eight guests present. The minutes of the last meeting were read and approved, and the minutes of the Board of Direction were also read for the information of the members.

The report of the Board of Direction, embodying the reports of the Outing Committee, Library Committee and Librarian, Secretary and Treasurer, was read and ordered filed.

Upon the attention of the meeting being called to the fact that our February meeting is scheduled for February 13, which happens to be the eve of Mardi Gras, it was resolved that it be postponed one week.

It being next in order the President read his annual address, which was profusely illustrated with lantern slides. It was most heartily applauded.

A recess of ten minutes was taken preparatory to the election of officers, after which, upon being called to order, the following officers were elected for 1899:

President—Thomas L. Raymond.

Vice-President—C. H. Chamberlin.

Secretary—J. F. Coleman.

Treasurer—Alf. F. Theard.

Mr. H. J. Malochee was elected as Director for a three-year term, vice Mr. F. T. Llewellyn, whose term has expired. Mr. Sidney F. Lewis was elected as representative on the Board of Managers of the Association of Engineering Societies for 1899. Mr. Raymond resigned from the Directorship in order to accept the Presidency, and the vacancy thereby created was announced, to be filled at the next regular meeting of this Society.

The thanks of the Society were extended Mr. Lewis by motion for his instructive address. And upon motion, duly seconded, it was resolved that the thanks and appreciation of the Louisiana Engineering Society be expressed to Mr. Sidney F. Lewis for his very able administration of its affairs during his term of office.

Adjourned.

J. F. COLEMAN, *Secretary*.

Montana Society of Engineers.

At the regular monthly meeting of the Society, held in Helena, Montana, on December 10, 1898, the fore part of the evening was devoted to business matters, after which a paper by Mr. Francis W. Blackford, upon his construction of the Butte-Centerville Electric Railway, was read and discussed.

A vote of thanks was extended to Mr. C. B. Nolan, Attorney-General of Montana, for his kindness in examining and giving his legal opinion upon the bill providing for a State Engineer; also to Mr. F. W. Blackford for his instructive paper.

A. S. HOVEY, *Secretary*.

Detroit Engineering Society.

DETROIT, MICH., JANUARY 24, 1899.—The thirty-sixth regular meeting of the Society was held at the Hotel Ste. Claire, Friday, January 20, 1899, at 8 P.M.

Mr. W. J. Keep, First Vice-President, was in the chair, and Mr. Henry Goldmark was Secretary. There were twenty-five members and guests present. The Executive Committee reported the following names of gentlemen proposed for membership, viz.: Mr. C. B. Stewart, Assistant Engineer U. S. Board of Engineers on Deep Waterways, Detroit; Mr. G. B. Mitchell, with the same Board.

The paper of the evening, on "Overhead Electric Conductors," was read by the author, Mr. Alex. Dow, general manager Edison Illuminating Company, of Detroit. It was discussed by Messrs. Steele, D. A. Molitor, Demrick, Field, Phillips and Dow, and by Mr. G. P. Nichols, of Chicago.

Adjourned.

THE Executive Committee met at the Hotel Ste. Claire, January 20, 1899. Present, Messrs. Keep, Dow and Goldmark.

The names of Messrs. C. B. Stewart and G. B. Mitchell were proposed for membership.

Bills of Richmond & Backus Co. and of Henry Goldmark were approved.

Adjourned.

HENRY GOLDMARK, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR MEETING, JANUARY 6, 1899.—Called to order at 8.30 P.M. by Vice-President Percy.

The minutes of the last regular meeting were read and approved.

On motion the action of the chairman of the Finance Committee and the Secretary in paying the sum of \$20 on account to George Spalding & Co. was approved.

Mr. C. E. Grunsky offered the following amendment:

"Resolved, That Section 1 of Article VII of the By-laws be amended to read as follows:

"Add to the said section the words:

"Provided, That persons eligible to membership who are temporarily stationed on the Pacific Coast shall be exempt from the payment of an admission fee."

The resolution was accepted and ordered voted upon at the next regular meeting according to the by-laws.

The following report of the Nominating Committee was read by the Secretary:

Your committee respectfully reports that it has made a careful canvass of the available names, and has been authorized by all of them in the ticket named below to report that if elected they will serve the Society in the offices as follows:

President—George W. Percy.

Vice-President—Hubert Vischer.

Secretary—Otto von Geldern.

Treasurer—E. T. Schild.

Directors—Louis Falkenau, T. W. Ransom, S. C. Irving, Hermann Barth, T. W. Brooks.

Respectfully submitted,

LUTHER WAGONER, *Chairman*.

The report was ordered accepted, and the Secretary instructed to prepare the necessary ballots for the election of officers to be held January 20.

The chairman appointed the following judges of election in accordance with Section 2, Article II of the By-laws: Luther Wagoner and D. C. Henny.

The Secretary was furnished with a list of available candidates for membership, and instructed to communicate with these gentlemen for the purpose of obtaining their names to increase the Society's membership.

Adjourned.

OTTO VON GELDERN, *Secretary*.

ANNUAL MEETING, JANUARY 20, 1899.—Called to order at 8.30 P.M. by President Molera.

The minutes of the last regular meeting and the last annual meeting were read and approved.

Messrs. Luther Wagoner and D. C. Henny, tellers appointed to count the ballots for officers for the ensuing year, announced the following ticket elected:

President—G. W. Percy.

Vice-President—Herbert Vischer.

Secretary—Otto von Geldern.

Treasurer—E. T. Schild.

Directors—Hermann Barth, Louis Falkenau, T. W. Ransom, Samuel C. Irving, Thomas W. Brooks.

The report of the Treasurer was read and ordered received and placed on file. The Secretary was granted two weeks further time to complete his annual report.

The resolution by Mr. C. E. Grunsky, proposed at the last regular meeting, that the by-laws be amended so as to admit professional men who may be temporarily stationed on this coast as members without the payment of an admission fee, was adopted upon motion. The Secretary was instructed to so modify the present by-laws as to show this clause, by pasting the slips containing the change between the proper leaves; also to send to each member of the Society the printed slip calling attention to this modification.

The Secretary was likewise instructed to write to the Secretary of the Association of Engineering Societies, requesting him to inclose a mailing list, showing the present membership of the Technical Society, to each member with the next circulation of the JOURNAL.

The application of Mr. F. C. Herrmann to become a member was referred to a regular monthly meeting of the Society.

Adjourned.

OTTO VON GELDERN, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., JANUARY 2, 1899.—The sixteenth annual meeting of the Civil Engineers' Society of St. Paul was held at 8.15 P.M. Nine members present. President Estabrook in the chair. Minutes of previous meeting read and approved.

Communications were acted upon as follows: From League of Associated Engineers and Albert Blauvelt, circulars and copy of H. R. 10,403 as to reorganization of naval personnel. Referred to committee, Powell, Münster and Annan, with power to act.

From J. J. R. Croes, letter transmitting various copies of reports, Librarian to file reports and Secretary to thank Mr. Croes.

From Secretary of the Association of Engineers of Virginia, letter announcing formal disbanding of Association.

Copy of Municipal and Railway Record referred to Librarian for examination.

The annual reports were read and accepted.

The Treasurer was authorized to pay \$10 for care of Society room, and the Secretary was instructed to write a letter of thanks to the joint commission for courtesies extended. The officers of the Society were re-elected and Mr. George L. Wilson was elected representative on the Board of Managers of the Association of Engineering Societies.

C. L. ANNAN, *Secretary.*

Civil Engineers' Club of Cleveland.

CLEVELAND, O., JANUARY 10, 1899.—The regular monthly meeting was held in Case Library January 10, at 8 P.M., with Past-President James Ritchie in the chair; present thirty-four members and five visitors. On motion of Mr. Culley the reading of the minutes was dispensed with and the minutes as printed were approved.

Messrs. Culley and McIntyre were appointed tellers to canvass ballots for members, and on receiving their written report the chair announced the election to active membership of Frederick Metcalf and Charles Olney Cook.

The Executive Board reported favorably upon the applications for active membership of Messrs. William Oswald Henderer, Wilbur Jay Watson, Ransome Tedrowe Lewis and William Martin Torrance.

Under the head of correspondence a letter received from the Civil Engineers' Society of St. Paul was read, showing that the Society had referred to a committee the subject of the reorganization of the naval personnel.

The committee appointed at the last regular meeting to investigate the question of new quarters made its report as follows:

REPORT OF SPECIAL COMMITTEE ON QUARTERS.

To the President and Members of the Civil Engineers' Club of Cleveland:

At the beginning of its investigations into the "feasibility of renting quarters in the new building of the Chamber of Commerce" your committee was confronted by the fact that no move of that kind could be made without increasing the income; and, to that end, a circular (a copy of which is hereto appended) was prepared and sent to each of the members.

The financial statement in this circular is based on the receipts and expenditures of the last fiscal year. Of the expenditures, two items, at least, are believed to admit of considerable reduction. The JOURNAL costs \$480 per year, and it is believed this can be reduced one-half by securing advertising.

The item for printing is believed to be fully fifty per cent. more than the strictly necessary requirements of the Club call for.

Sixty-four responses, all favorable, have been received to this circular, of which four are from associate members, and four are conditional. Of the remaining number fifteen are out of town, and sixty-nine have expressed no views, in writing. Of these sixty-nine the committee are of the opinion, from information gained by interviews, and otherwise, that forty-six are either in favor of the proposition, or at least are not actively opposed to it; of twenty-three no opinion of any kind could be formed. Five members only have expressed opposition, based in every case, on the increase of the dues, and in one or two cases on the prospective severing of our relations with Case Library.

So far as the latter objection is concerned the committee believe that it can be easily removed. Two courses are open to the Club; one to continue the present arrangement, as to the purchase of books, with Case Library, the other for the Club to undertake the accumulation of a reference library of its own.

The committee did not consider it within the scope of its duties to investigate this question exhaustively, and therefore has no recommendation to

make in this connection. As to the objection to the increased dues, the committee is of the opinion that the benefit to be derived is very much greater in proportion than the increase in the dues. A large proportion of the members feel that they are not getting benefits at all commensurate with the present dues, and it is believed that a good deal of this dissatisfaction would be removed by acquiring commodious, well-furnished quarters that would always be available, exclusively to members. The privilege of the chamber restaurant and the identification of the Club, to a certain extent, with the chamber, are believed to be advantages that will appeal forcibly to our more progressive and active members and to many whom we hope to enroll if this proposition be adopted.

A suggestion has been made that an assessment of \$5 be levied in lieu of amending the constitution. In favor of this it may be said that in the event of a large accession of members or of an unforeseen reduction of expenses it might not be necessary to increase the dues at all; but, on the other hand, it may be urged that assessments, in general, are impolitic, and that the members will receive benefits fully commensurate with the increased dues. Any surplus, too, could always, under good management, be used to good advantage to increase still further the benefits to the members.

The committee does not consider the securing of new quarters to be a panacea for all the ills from which the Club is suffering. These evils are due to the dry rot engendered by the total indifference of a large proportion of the members for a long time past, and as to the cause of which your committee expresses no opinion. It is the opinion, however, that the securing of the new quarters in question will be a long step toward improved conditions; and that then, with a management which shall seek and put into effect every practicable idea for the betterment of the Club, and with the hearty and united co-operation of all its members, the Club will become what it ought to be, the recognized authority on all questions pertaining to the profession in this city, and a body to which every one of its members will feel it an honor and a privilege to belong.

As the option which has been secured on these rooms expires to-morrow, and as these rooms, at the very longest, will not probably be available longer than for a few days, your committee respectfully recommend the adoption of a resolution at this present meeting looking to the closing of an agreement with the Chamber of Commerce looking to the renting of these rooms.

JOS. C. BEARDSLEY,
W. R. WARNER,
W. B. COWLES,
Committee.

JANUARY 10, 1899.

CIRCULAR.

DECEMBER 20, 1898.

To the Members of the Civil Engineers' Club of Cleveland:

Your attention is respectfully requested to the following statement and proposition respecting new quarters for the Club:

If action be taken *at once*, rooms can be secured in the new building of the Chamber of Commerce. The use of these rooms will include the use of the smaller auditorium of the chamber (known as the council room), when necessary, and the privilege of the chamber restaurant.

The rooms which your committee consider most desirable are on the fifth floor next to the Society for Savings Building, are three in number, containing about 1150 square feet of floor space, and costing \$1200 per year. The smallest of these might be used for the office of the Secretary, as contemplated in the annexed financial statement. The largest is large enough for all the usual meetings of the Club, and the third could be used for a library and reading room.

The advantages of this change for the Club are that it secures a home (which it has never so far had) in the most central and easily accessible locality in the city.

We should have all the benefits and advantages of a first-class club at a trifling advance over our present dues and without any of the uncertainty and care incident to maintaining a club house of our own. Arrangements could no doubt be made to have lunches served in our own rooms after meetings, etc., if it should seem desirable.

In view of the arrangement contemplated to be made as to the Secretary, it would not be necessary to hire an attendant to look after the room, all janitor service being rendered, without extra charge, by the chamber. Each member will be provided with a key to the rooms.

It is believed that all this can be secured by increasing the dues \$5 per year, and an amendment to the constitution to this effect will be introduced at the January meeting.

As the time during which these rooms will be available is limited, your committee believe that the only way to secure this opportunity is for the members individually to agree to pay for one year the amount necessary in excess of the present dues. If a sufficient number are willing to do this it follows that the success of the amendments is assured.

The financial statement and estimate appended is based on the last annual reports of the Secretary and Treasurer.

RECEIPTS.	
General (dues)	\$1,598 44
Permanent (entrance)	172 05
Library (voluntary subscription).....	120 00
	<hr/> \$1,890 49
EXPENSES.	
Rent and lighting	\$1,250 00
Journal	480 00
Printing (omitting banquet)	337 45
Stationery	46 07
Postage and express	88 35
Memorials and certificates	45 90
Allowance to Secretary to cover clerical work in addition to use of office allowed him for his personal business	100 00
Incidentals	52 23
	<hr/> \$2,400 00
Annual allowance for furniture and fixtures (permanent fund)	170 00
Annual allowance for library based on last year's subscriptions	120 00
	<hr/> 290 00
Total expenses	\$2,690 00

Leaving a deficit of \$800, which may be met as follows:

150 active members at \$5.....	\$750 00
20 associate members at \$5.....	100 00
Total	<u>\$850 00</u>

Leaving a margin of \$50 for contingencies.

This statement excludes all items of the social account. The permanent fund, amounting on March 1, 1898, to \$722, is available for the immediate needs of the Club as to furnishings.

J. C. BEARDSLEY,
W. R. WARNER,
W. B. COWLES,
Committee.

Mr. Culley moved that the report be received. This was seconded.

Mr. Beardsley moved as an amendment that the report be received and adopted.

Professor Langley offered as a further amendment that the report be laid on the table. This amendment was lost.

A discussion ensued on Mr. Beardsley's amendment in which Messrs. Baker, Beardsley, Culley, Hopkinson, Hyde, Parmley, Skeels and Professor Langley took part. On calling for the question there were thirteen ayes and twelve nays, and on the adoption of the original motion there were fourteen ayes and thirteen nays, and the chair declared the report adopted.

Under the head of miscellaneous business the question of the proper action of the Club on the committee's report was discussed. It was moved by Mr. Beardsley that the Executive Board be authorized and directed to enter into an agreement with the Chamber of Commerce for the renting of the three rooms which have been in question during this discussion.

Mr. Culley offered as an amendment that the question be submitted to letter ballot, to be canvassed at the semi-monthly meeting in January. This amendment was seconded and fully discussed. On being put to vote it was lost.

The original resolution, having also been discussed while the amendment was pending, was then put to vote, and was adopted by fifteen ayes and eleven nays.

The Club then proceeded to choose a Nominating Committee to report a ticket for the coming year. The following names for the committee were offered by different members present: John L. Culley, Joseph C. Beardsley, William B. Cowles, A. Lincoln Hyde, Harry A. Nelson, Samuel J. Baker, Walter C. Parmley. No other names being offered, on motion the nominations were declared closed, and it was voted that the seven members named should constitute the Nominating Committee.

The hour being late, Mr. Hyde, seconded by Mr. Cowles, moved that the paper of the evening be postponed to the regular meeting in February in order that proper justice might be done to the subject. The motion was carried. The Club then adjourned at 10.15 for conversation and lunch.

WILLIAM H. SEARLES, *Secretary.*

THE semi-monthly meeting was held in Case Library, Tuesday, January 24, at 8 P.M.; present nineteen members and six visitors; President Osborn in the chair. Mr. William B. Cowles, member of the Club, read

the paper of the evening, entitled "The United States Navy; Personnel Reorganization its Greatest Need." He gave a brief glance at the history of our navy, showing its greater relative importance in the earlier days of the republic until the development of the vast interior of our country absorbed our attention and drew largely upon our resources. The latest statistics show the United States Navy to rank fifth in the world by tons displacement, while its merchant marine ranks second. The material of our navy is excellent, but the quantity is far too small. The author described the nine corps among which the naval officers are distributed and referred to the differences existing under the present law between the line and staff, particularly between the line and engineers. These differences in rank cause needless incongruities and complications in duty and unjust postponement of promotion, while the differences in pay are unjust alike to the juniors of the line and the seniors of the engineers. The bill (H. R. 10,403) now pending in Congress will unquestionably cure these and many other existing evils and give to our navy a homogeneity and efficiency unequaled in the world.

The paper was earnestly discussed, and a resolution was adopted advocating the passage of the bill in question.

At 10.30 the Club adjourned and lunch was served.

WILLIAM H. SEARLES, *Secretary*.

ASSOCIATION OF ENGINEERING SOCIETIES.

VOL. XXII.

FEBRUARY, 1899.

No. 2.

PROCEEDINGS.

Civil Engineers' Club of Cleveland.

REGULAR MEETING, FEBRUARY 14, 1899.—The regular monthly meeting was held in Case Library on February 14, 1899, at 8 P.M.; President Osborn in the chair. Present, thirty-two members and seventeen visitors. On motion, the reading of the minutes of the January meetings was dispensed with.

Messrs. C. O. Palmer and H. S. Nelson were appointed tellers to canvass ballots received. They reported the election to active membership of Messrs. William Oswald Henderer, Wilbur Jay Watson, Ransome Tedrowe Lewis and William Martin Torrance.

The Executive Board presented the name of Allan Wadsworth Carpenter as candidate for active membership. The board reported that action regarding leasing rooms of the Chamber of Commerce had been deferred until a reply was made to a tender for joint use of rooms, made by the board to the Electric Club. The board recommended that the annual banquet be omitted this year, and that a social function be held instead in the new rooms of the Club when opened.

A letter from the Electric Club was read, in which a proposition to rent jointly four rooms on the sixth floor of the Arcade was submitted.

The Committee on Rooms made an informal report. The Committee on Nominations reported the following ticket to be voted on in March:

For President—Col. Jared A. Smith.

For Vice-President—Dr. John W. Langley.

For Secretary—Arthur A. Skeels.

For Treasurer—John N. Coffin.

For Librarian—William E. Reed.

For Directors, two years—Joseph R. Oldham, William B. Hanlon.

On motion, the report was received.

Mr. A. L. Hyde moved a reconsideration of the vote of the Club at the last regular meeting upon the motion of Mr. Beardsley authorizing and instructing the Executive Board to enter into an agreement with the Chamber of Commerce for the renting of three rooms. The reconsideration was ordered.

Mr. Hyde moved that Mr. Beardsley's motion be laid on the table. Seconded and carried.

Mr. Hyde, seconded by Mr. W. B. Cowles, moved that the Committee on Rooms be enlarged by the addition of four names, and that its duties be extended to include the consideration of rooms elsewhere than in the Chamber of Commerce building. Carried. The President named Messrs. L. B. Hoit, Wm. E. Reed, John N. Coffin and C. W. Hopkinson to be added to this committee.

Professor Robert H. Fernald read the paper of the evening, "Experiments on the Efficiency of Bicycles," describing investigations made at the Case School of Applied Science, and giving certain conclusions arrived at. Comparisons were drawn between chain and chainless bicycles, racing and road wheels, between sprockets of different size, and tires under different air-pressures. Diagrams showing relative efficiency were exhibited.

The subject was discussed by Dr. Langley, Professor Benjamin, Mr. S. T. Dodd and others.

Mr. Hyde moved that a banquet committee of seven be appointed. Seconded and carried.

Mr. Reed moved that the committee use its discretion as to having a banquet or reception. Seconded by Mr. Beardsley and carried. The President said he would announce the members of this committee later.

The President announced that the members and visitors present were invited to inspect the rooms of the Board of Underwriters in the Arcade, which are for rent, and then to take lunch at Stranahan's.

Adjourned at 9.30 P.M.

WILLIAM H. SEARLES, *Secretary*.

NOTE.—On February 23 the President appointed Messrs. James Ritchie, S. Lincoln Hyde, Aug. Mordecai, John R. Richardson, Dr. Perry L. Hobbs and Edwin S. Mills as a Banquet Committee.

SPECIAL MEETING, CLEVELAND, FEBRUARY 28, 1899.—The semi-monthly meeting was called to order at 8.15 P.M.; Past-President Ambrose Swasey in the chair. Present, thirty-three members and two visitors. The minutes of the last meeting were read and approved.

The report of the Committee on New Quarters having been made the special order for this meeting was called for. The chairman, Captain Beardsley, stated that he had but a part of the papers with him, Mr. Reed having the rest of them, and he had not yet arrived. Mr. Ritchie moved that the report be now read. This was seconded, and on being put to vote was lost.

Mr. Joseph R. Oldham then read the paper of the evening on "The Rise and Fall of the American Merchant Marine," which abounded in interesting facts as to the past and glowing anticipations for the future. The subject was discussed by Messrs. Howe, Green, Culley, Searles and the author.

The report of the Committee on New Quarters being again called for, its chairman stated that the committee had been unable to agree upon a report, and consequently had none to make. It had held several meetings, but had come to no conclusion. At a joint meeting of the committees of this and other technical societies of Cleveland two plans had been proposed, and a resolution in favor of each adopted by the Joint Committee, which he then read, and submitted to the Club.

Mr. Culley, seconded by Mr. Hyde, moved that the report of the Joint Committee be received. Carried.

Mr. Ritchie, seconded by Dr. Howe, moved that the report be taken up by sections and discussed. Mr. Hyde moved as an amendment that the Club consider the two resolutions of the joint committee. It was so ordered, and the motion as amended was carried.

Dr. Howe moved, as to the first resolution, that it is the sense of this meeting that it would be unwise at present to discuss an amalgamation of the technical societies of Cleveland. Seconded and carried.

Mr. Culley moved that the Club approve of the second resolution of the Joint Committee, and that the President appoint a committee of five to carry out the plan submitted. Seconded by Mr. Hopkinson.

Mr. Parmley objected that the duty of the committee was to report on rooms and not on a plan of federation.

Mr. Hyde said its duty was also to get at the sentiment of the other societies on the subject.

Captain Beardsley said his committee had been unable to agree on a location for new quarters.

Mr. Hopkinson was in favor of confederating with other societies in accordance with the plan submitted.

Mr. Searles spoke in favor of the Club taking quarters of its own at once, because it greatly needs them, and is abundantly able to pay for them without making any assessment, and without the assistance of other societies; leaving the question of federation to be solved at leisure in the future. The experience of this committee shows how difficult it may be to bring all four societies to a common conclusion, or to a harmonious management in common quarters.

Mr. Warner objected to the last remarks, and believed that the scheme was feasible as a business proposition.

Dr. Langley quoted the experience of the Society of Engineers of Pittsburg, where a plan of federation with other societies had succeeded well, and an entire house had been occupied by them.

Dr. Howe spoke of this plan as the first one of the several heretofore considered that seems to give prospect of success.

Mr. Coffin was opposed to federation, but favored the idea of consolidation of all into a new body with one central management.

Mr. Oldham thought federation was unnecessary if this Club would take the lead as the oldest and strongest of them all. Its constitution was broad enough to include the members of the others if they were inclined to come in. Only let us get rooms of our own.

Dr. Howe objected to the clause in the plan offered which provides that the members of each society be associate members of each of the other societies, and moved as an amendment that this clause be struck out. Amendment agreed to by Culley and Hopkinson.

Mr. Ritchie said it would be unconstitutional for this Club to create a Board of Directors as provided in the plan.

Dr. Howe explained that the proposed board was for the purpose of managing the joint property of the federation; it was a business proposition merely, and did not disturb the internal affairs of either society.

After further discussion the question was put to vote and carried. On motion the Club then adjourned at 10.30 P.M., before the President had time to announce the committee provided for in the resolution.

The plan and resolution, as approved by the Club, reads as follows:

Skeleton plan for the federation of the scientific societies of the city of Cleveland:

SOCIETIES TO BE ASSOCIATED.

The Civil Engineers' Club of Cleveland.
 The Electric Club of Cleveland.
 The Cleveland Architectural Club.
 The Cleveland Chemical Society.
 and such other technical societies as may wish to join.

OBJECTS TO BE GAINED.

Mutual improvement, wider acquaintance, closer relationship, broader views, more weight in the community, common quarters, better and larger attendance of all meetings, and as a result better papers prepared with more care, better general results without increased expense.

FINANCES.

Expense of hiring commodious quarters with suitable custodian or clerk and the issuing of a bulletin giving dates of meetings, titles of papers and other information of general interest to be borne jointly by the societies interested and in the ratio of their memberships. This expense not to exceed \$4 per capita per annum.

INDIVIDUALITY.

Each society to retain its present individuality as regards its name and constitution and by-laws, the latter to be so amended as not to conflict with the objects to be gained.

MANAGEMENT.

The affairs of the federation to be managed by a Board of Directors made up from the societies represented in the ratio of one representative for each fifty active members or fraction thereof, of the respective societies, together with one member at large from each society.

Resolved, That it is the sense of this Joint Committee that the plan herewith submitted for a joint occupancy of room, if approved by the membership of each of the four societies represented on the committee, can be speedily arranged.

WILLIAM H. SEARLES, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR MEETING, FEBRUARY 3, 1899.—Called to order at 8.30 P.M. by Past-President Molera.

The minutes of the last regular meeting and of the annual meeting were read and approved.

The following associate members were declared elected by ballot: Joseph F. Forderer, of Alameda, and John J. Mahoney, of San Francisco.

Three applications for membership, Herman, Fraser and Ballantyne, and five applications for associate membership, Butcher, Day, McPhee, McGilvray and Masow, as laid before the Board of Directors, were read and ordered to take the usual course.

Past-President Molera then addressed the Society, reviewing briefly the work done and the efforts made during the past year, reverting at length to the financial standing and to the absolute necessity of raising a fund of \$400 to liquidate the long-standing indebtedness of the Technical Society. Half the sum, he stated, had been realized by obtaining two life members upon a payment of \$100 each, and it remained for the members

to raise the amount of \$200 only. He made the proposition that if the individual members would start a subscription for voluntary contributions, he would agree to pay the balance of what such contribution might lack to complete the sum required.

Mr. Grunsky moved that any contribution made by a member, together with the dues for 1899, shall be construed as a payment on a life membership, should the member conclude to become one during this year. Seconded and carried. The following contributions were then offered: G. W. Percy, \$10; E. J. Molera, \$10; Hubert Vischer, \$10; A. J. McNicoll, \$10; Otto von Geldern, \$5; Hermann Barth, \$5; T. W. Brooks, \$10; S. C. Irving, \$10; Adolf Lietz, \$10; E. T. Schield, \$10; A. D'Erlach, \$5; C. E. Grunsky, \$10; total, \$105.

It was ordered that the list be kept open until the next regular meeting for further voluntary contributions.

Mr. Molera introduces the President-elect, Mr. Percy, who takes the chair, congratulates the members and thanks Mr. Molera for his generous offer and constant assistance to place the Society upon a firm footing.

The report of the Secretary, including that of the Treasurer, for the year 1898, was read and ordered received and placed on file.

A communication from Prof. W. B. Rising, of the University of California, was read, in which he requests the Society to assist him in securing samples of fuels of the Pacific Coast, and in gathering certain data as to the evaporation test, and for the determination of the absolute heat value, etc.

Upon motion, it was ordered that a committee of three be appointed to give Professor Rising any assistance possible in this line, and that the Secretary be instructed to communicate with him and to inform him of the action of the Society. The chair thereupon appointed the following committee: Luther Wagoner, John Richards and H. C. Behr.

Mr. Grunsky read a letter from Mr. F. H. Newell, Hydrographer United States Geological Survey, calling attention to an act authorizing the appointment of a Commissioner of Irrigation by the State, to co-operate with the Director of the United States Geological Survey in surveys and estimates of costs of reservoirs for storing flood waters for irrigation, mining and industrial purposes, and appropriating money to carry out the provisions of this act.

The Secretary then proceeded to read the act, consisting of seven sections, after which a short discussion followed without action.

Mr. Grunsky spoke of the proposed effort to remodel the State Board of Harbor Commissioners, and referred to the apparent necessity of certain changes in its administrations.

Adjourned.

OTTO VON GELDERN, *Secretary*.

DIRECTORS' MEETING, FEBRUARY 3, 1899.—Called to order at 4.15 P.M. by President Percy. Present, Directors Percy, Vischer, Ransom, Irving, Barth and von Geldern. The chair appointed the following committees:

Executive—Vischer, Falkenau and Brooks.

Finance—Barth, Ransom and Irving.

As Managers on the Board of the Association of Engineering Societies Messrs. D. C. Henny and Otto von Geldern were appointed by the chair.

The Secretary was instructed to write to Prof. Frank Soulé to make inquiry as to the present status of the Committee on Pacific Coast Timbers.

The following applications for membership were made and ordered to be read at the regular meeting of the evening:

For members:

1. A. B. Ballantyne, Superintendent of Lighthouse Construction, San Francisco. Proposed by Otto von Geldern, Hubert Vischer and C. E. Grunsky.

2. F. C. Herrmann, civil engineer, Gilroy. Proposed by C. E. Grunsky, Otto von Geldern and H. C. Behr.

3. E. M. Fraser, electrical engineer, San Francisco. Proposed by Hermann Barth, A. J. McNicoll and G. W. Percy.

For associate members:

1. John D. McGilvray, contractor, Palo Alto. Proposed by Hermann Barth, G. W. Percy and Otto von Geldern.

2. Frank H. Masow, builder, San Francisco. Proposed by G. W. Percy, S. C. Irving and Otto von Geldern.

3. Daniel McPhee, contractor, San Francisco. Proposed by S. C. Irving, G. W. Percy and Otto von Geldern.

4. Charles A. Day, builder, San Francisco. Proposed by S. C. Irving, T. W. Ransom and Otto von Geldern.

5. Thomas Wm. Butcher, builder, San Francisco. Proposed by Hermann Barth, T. W. Ransom and S. C. Irving.

No further business appearing, the meeting adjourned.

OTTO VON GELDERN, *Secretary*.

Engineers' Club of St. Louis.

484TH MEETING, FEBRUARY 1, 1899.—The meeting was called to order at 8.15 P.M.; President Colby in the chair. Twenty-seven members and eight visitors were present.

The minutes of the 482d meeting were read and approved. The minutes of the 269th meeting of the Executive Committee were read. The application of Mr. H. S. Wilson having been approved by the Executive Committee, he was balloted for and declared elected a member of the Club. The applications for membership of Mr. George A. French and Mr. Charles A. Tripp were announced. The resignation of Prof. J. B. Johnson as a member of the Board of Managers of the Association of Engineering Societies was read and accepted, as was the resignation of Mr. Elliott Jones as a member of the Club.

The donation of "The Science of Modern Cotton Spinning" in two volumes by Messrs. T. G. Meier and E. D. Meier, and Vol. XXVII of the Transactions of the American Institution Mining Engineers by Mr. E. D. Meier, were announced, also some reports on Water Supply and Sewerage by Mr. J. James R. Croes.

Mr. H. S. Wilson then read the paper of the evening, entitled the "Production of Seamless Tubing." Mr. Wilson dealt with the kinds and characteristics of the ore needed and some of the requisite processes of its reduction to make the grade of steel necessary for drawing seamless tubes. The various methods of getting the hole in the billet were explained and the main characteristics of the more important machines used for this purpose were set forth.

The annealing and pickling processes were described and the delicacy of the operation shown. The drawing benches, with their attendant drawing devices, the number of reductions necessary, the kinds of lubricants used, etc., were all fully gone into, and interesting reasons for many troubles which arise given. Mention was made of the great variety of grades and sizes of tubes and the care necessary to keep them separate in the factory. The processes for the production of lead, brass and copper tubes were also touched upon. Sketches on the blackboard illustrated graphically and clearly the various points and a few samples showed how the reductions are made. There being no further business, the meeting adjourned to another room, where a light lunch was served.

E. R. FISH, *Secretary*.

485TH MEETING, FEBRUARY 15, 1899.—The meeting was called to order at 8.20 P.M.; President Colby in the chair. Forty-three members and twenty visitors were present. The minutes of the 484th meeting were read and approved. The minutes of the 270th meeting of the Executive Committee were read. The names of Messrs. V. K. Hendricks, H. B. Shaw, W. A. Bennett and F. F. Astell were proposed for membership. Messrs. Chas. A. Tripp and George H. French, having been recommended by the Executive Committee, were balloted for and declared elected members of the Club. Messrs. Bryan, Laird and Connor were nominated as a member of Board of Managers of the Association of Engineers Society. Vote was taken by ballot, and Mr. Bryan was declared elected to the position, the vote being Bryan, 27; Laird, 8; Connor, 8; McCulloch, 1.

Mr. M. L. Holman then opened the discussion of the evening on the Chicago Drainage Canal, giving a brief description of main features of Chicago's sewerage system, the Chicago River and the canal itself. He also read parts of the law, giving the provisions for the construction and taxation to pay for it.

Mr. R. E. McMath further elaborated the subject, showing the relation of the Desplaines River, the Illinois and Mississippi Canal and the Drainage Canal. He also discussed some of the early attempts of Chicago to gain relief from the sewerage. The effect of the canal in a commercial way was touched upon.

Mr. Holman added some further remarks on the engineering fallacies of the scheme as undertaken. He stated that the original plans had not been followed out and mentioned that the Chicago engineers themselves do not see the way clear to successful fulfillment of the original expectations. Mr. Colby also added a few remarks.

There being no further business, the meeting adjourned to another room, where lunch was served.

E. R. FISH, *Secretary*.

Engineers' Club of Minneapolis.

MINNEAPOLIS, MINN., FEBRUARY 13, 1899.—The regular monthly meeting of the Engineers' Club of Minneapolis was called to order in the parlors of Hotel Hyser, at 8.15 P.M. President Cappellen not being present, City Engineer G. W. Sublette was elected presiding chairman of the meeting. The minutes of the last meeting were read and approved. Several letters of interest to the Club were read by the Secretary. Upon

motion of Mr. Redfield, the notice of the St. Paul Society regarding the trip of inspection of the Bronsdon Car Raising Device, which this Club participated in, was spread upon the minutes of the Club.

Prof. G. D. Shepardson then read his annual report as member of the Board of Managers of the JOURNAL. Upon motion, the report was filed. The Treasurer then presented his annual report, as follows:

RECEIPTS.

Balance received from last Treasurer.....	\$51 36
Cash from initiation fees, 9 new members.....	45 00
“ JOURNAL subscriptions.....	6 00
Total	\$102 36

EXPENDITURES.

For postage and printing.....	\$11 03
“ rooms at Hotel Hyser.....	12 00
“ four annual assessments paid to J. C. Trautwine on JOURNAL account	32 25
“ binding 8 vols. Journal of the Association Journal for Library of Club	4 80
Total	\$60 10

Total cash in my hands February 13, 1899..... \$42 26

It was moved that the report be sent to the Auditing Committee.
Carried.

County Surveyor G. W. Cooley then read a very interesting paper upon “A Study of the Hydrography of Lake Minnetonka.”

It was moved and carried that Mr. Cooley’s paper be printed in the JOURNAL. As the hour was getting late it was decided to postpone the election of officers until the following meeting.

There being no further business, the meeting was adjourned.

HARRY E. SMITH, *Secretary*.

Civil Engineers’ Society of St. Paul.

ST. PAUL, FEBRUARY 7, 1899.—A regular meeting of the Civil Engineers’ Society of St. Paul was held at 8 P.M. Present thirteen members and one visitor. Minutes of previous meeting read and approved. A verbal report of Committee on Naval Personnel Bill was accepted and committee discharged. President Estabrook then called on Mr. Hogeland, who read a paper on “Locomotive Coaling Stations.” He illustrated by drawings and photographs the evolution of coal handling for locomotive use on the Great Northern Railway. Beginning with the primitive derrick and bucket system, which was worked at an expense of 17 cents per ton, he advanced through various stages (1) shoveling into chute pockets; (2) dumping and chain conveying to chutes; (3) dumping directly into chute, coal car being raised by 15 H. P. gasoline engine. The Great Northern moves 750,000 tons annually through chute pockets of five or six tons capacity at an average cost of 3 cents per ton by measurement. Mr. Truesdell followed Mr. Hogeland with a description of im-

provement at the South St. Paul stock yards, 172 acres in extent, bounded on the river side by $1\frac{3}{4}$ miles of levee. The level of the yards is several feet below high-water mark, and has been flooded to the depth of 3 feet, but now the five sewer outlets may be closed by gates, and pump wells have been provided in case of flood. Nine artesian wells supply water. Swift & Co.'s immense packing establishment and half a dozen minor concerns do a rushing business on the site. An electric lighting plant turns night into day when necessary. Mr. Wilson having in the meantime arranged a vast exhibit of asphalts, crude and refined, rock plaster and semi-liquid, passed around prints and photographs and proceeded to say a few words on the sources of American asphalts. Trinidad, Bermudez, Kentucky, California and Utah deposits were considered physically, chemically and geologically, but briefly, as the hour was late.

C. L. ANNAN, *Secretary*.

Detroit Engineering Society.

THE thirty-seventh regular meeting of the Society was held at the Detroit Art Museum, Friday, February 24, 1899, at 8 P.M. A large number of invitations was sent out, and the presence of ladies was specially requested. The audience numbered about two hundred.

Mr. Geo. Y. Wisner, President of the Society, presided. Messrs. C. B. Stewart and G. B. Mitchell were elected as members.

The paper of the evening was then presented by the author, Mr. B. S. Colburn, erecting engineer of the Detroit Bridge and Iron Works. Its title was "The Erection of the Victoria Jubilee Bridge over the St. Lawrence at Montreal." The paper was illustrated by stereopticon views, nearly 50 in number, from photographs taken by the author, and showing all the details of the erection.

Adjourned.

HENRY GOLDMARK, *Secretary*.

A MEETING of the Executive Committee was held at the Detroit Art Museum, Friday, February 24, 1899; present, Messrs. Wisner, Keep, Pope, Hinchman and Goldmark.

Bills due the following persons were approved and ordered paid:

John Bornman & Sons.....	\$36 00
Field & Hinchman.....	4 59
Henry Goldmark	5 00
B. S. Colburn	10 00
Association of Engineering Societies.....	23 25

Adjourned.

\$78 84

Montana Society of Engineers.

THE regular monthly meeting of the Society was held in its rooms, in the Union Bank Building, Helena, Montana, on February 11, 1899. Meeting called to order at 8.30 P.M.; Mr. Elliott H. Wilson in the chair. The minutes of the twelfth annual meeting were read and approved. The applications for membership of Winfield J. Flood and William Zaschke were favorably considered and the Secretary instructed to send out the

usual letter ballots. Messrs. E. C. Kinney and J. S. Keerl were appointed tellers to canvass the ballots for membership. Twenty-five votes were cast, all affirmative, and William H. Harrison, Carlisle Mason, John D. McLeod, Charles H. Repath and Charles D. Vail were declared elected. A committee, consisting of Messrs. E. H. Wilson, A. S. Hovey and C. W. Goodale, appointed at the twelfth annual meeting to report upon the feasibility of changing the headquarters of the Society, and also of holding a part of the meetings in Butte and other places during the present year, submitted their report. They recommended that special meetings of the Society be held in Butte on the second Saturday of March and the second Saturday of every two months thereafter during the present year. The report was adopted. A question arising as to what business could be transacted at these special meetings, resolutions were adopted that at these special meetings any business of the Society should be transacted or papers read and discussed the same as at any regular meeting.

The Pettigrew amendment was read and discussed.

The proposed amendment to the "Sundry Civil Expense Bill" being as follows: "55th Congress, third session, H. R. In the Senate of the United States, January 5, 1899. Referred to the Committee on Public Lands and ordered printed. Amendment intended to be proposed by Mr. Pettigrew to the bill (H. R.) making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1900, and for other purposes,—viz, insert the following: 'That the fees of a United States Deputy Surveyor for surveying, platting and certifying to a mining claim, where the claimant wishes to obtain a patent therefor, shall not exceed \$30 for one claim, or \$7 per day for each day actually and necessarily employed in such work.'"

The Secretary reported that 1000 copies of this amendment and circular letters had been printed and sent out by the Society. They had been sent to the members of the Society and to every United States Deputy Mineral Surveyor in the State, and in quantities for distribution outside of the State, as follows: To all the United States Surveyor-Generals, to the Denver Society of Civil Engineers and the Technical Society of the Pacific Coast; also to a few United States Deputy Mineral Surveyors in each of the Western mining States. Responses received showed that they had been thoroughly distributed. Numerous correspondence and copies of letters and petitions to Congressmen were proof of the energetic efforts of the engineers to defeat this intended class legislation.

The charges for surveying in Montana are from \$10 to \$15 per day. A lode claim frequently embraces from ten to fifteen locations. To make a survey of such a claim and work up the returns for the United States Surveyor-General's office would require three or four weeks' time, and would require two or three assistants. The charges of the United States Surveyor-General for merely making a copy of the returns in Montana is \$30 for each location. His charges for a claim embracing ten locations would consequently be \$300. Placer claims are frequently more complicated than lode claims. One of the members referred to United States Survey No. 1348, of the Turnley Placer, near Elkhorn, Mont. It has 143 courses. This was a survey of a single location, which contained 160 acres of ground. He thought that not less than two months' time would be required to make the survey and prepare the returns for the United States Surveyor-General's office.

The Government does not pay the deputy for his survey, but he is paid by the claimant, or it is in the nature of private surveying work, consequently United States Surveyor-General Beattie, of Montana, considered it class legislation and unconstitutional.

In a letter from United States Surveyor-General Penault, of Idaho, he states, "I am opposed to all legislation of this character, as it cannot apply to all classes of cases, and I cannot see any greater reason for fixing by law the compensation of a deputy for surveying a mining claim than I can for regulating the compensation for services of any other professional man."

Mr. Wilson stated, "No part of this expense or responsibility thereof is borne by the Government, the surveyor not being a salaried officer of the Government, but, as an individual, making merely a private contract with claimant.

The United States Surveyor-General issuing an order to make the survey, and approving the returns, if upon examination they are found to be correct. The work involved in these surveys differs greatly. I have devoted twenty days' arduous labor, in field and office, to one such survey; again I have completed one such survey in one day."

Deputy Chase stated, "If the bill could be enforced it would not secure the object supposed, as it would result in driving all responsible deputies out of the business."

No further business offering, the meeting adjourned.

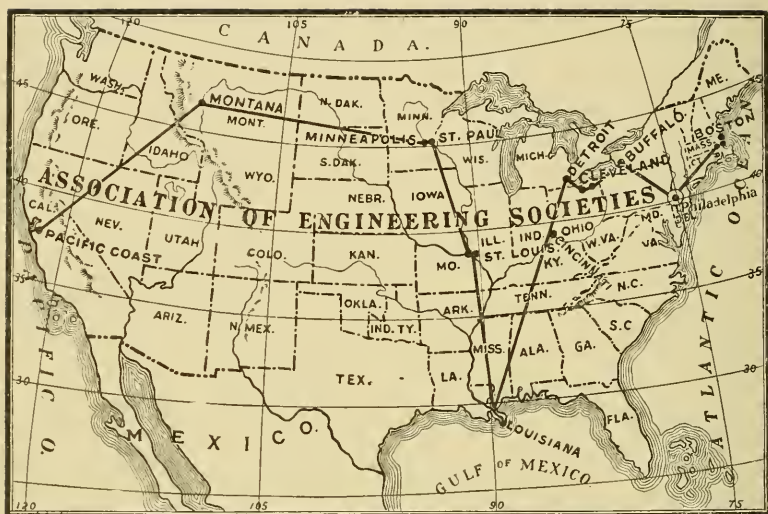
A. S. HOVEY, *Secretary*.

Engineers' Society of Western New York.

BUFFALO, N. Y., FEBRUARY 25, 1899.—The Engineers' Society of Western New York entertained at the rooms of Builders' Exchange the Buffalo Chapter of Architects and the Society of Artists.

At our regular meeting, in Buffalo Library rooms, March 6, 1899, Mr. F. V. E. Bardol, Chief Engineer of the Department of Public Works, opened the discussion on "The Abatement of the Hamburg Canal." Owing to short notice and pressure of other work, no formal paper had been prepared, so Mr. Bardol talked informally upon the question, which manner of treatment proved to be very interesting and instructive, as many questions were presented. As many of our readers know, the abatement of the Hamburg Canal has been a question of long standing in Buffalo, and as the present plans involved an expenditure of over \$700,000 they were presented to Mr. Rudolph Hering for critical examination, he having been called in by the city as consulting engineer. We are pleased to note that the plans, as prepared by Mr. Bardol, Chief Engineer, and Mr. A. W. Hoffman, Assistant Engineer, were approved in general by Mr. Hering.

H. J. MARCH, *Secretary*.



ASSOCIATION OF ENGINEERING SOCIETIES.

VOL. XXII.

MARCH, 1899.

No. 3.

PROCEEDINGS.

Montana Society of Engineers.

THE twelfth annual meeting of the Society was held in Helena, Mont., January 12-14, 1899.

A meeting was held in the Chamber of Commerce rooms on January 12, beginning at 9 P.M., F. W. Blackford in the chair. After reading the minutes of the preceding meeting, and disposing of certain business matters, the bill providing for a State Engineer and defining his duties was presented by Messrs. F. W. Blackford, John Herron and F. L. Sizer, the committee who drafted it, and was read section by section and discussed.

Prof. W. H. Williams offered, as an amendment to Section 15, "And the State Engineer shall be *ex-officio* a member of the State Arid Land Commission."

Seconded by Mr. Keerl.

MR. KEERL.—In the second Legislative Assembly a bill was introduced providing for the bonding of the State for \$10,000,000, dividing it into two departments, one east of the main divide and one west, \$6,000,000 to apply to the portion east of the divide and \$4,000,000 to the west. That bill was submitted to the Society by the framers, and the Society's views upon it were asked. The Society naturally took a lively interest in it, and criticised it in many of its features, largely for the reason that it could not see that the State's interests were at all protected in the expenditures of such large amounts of money, in the first place, and secondly, that there was no provision made qualifying the commissioners. We took very strong grounds on that point, and the same parties that were subsequently interested in the bill that is now a law used the same general arguments,—that it was not desirable to have an engineer upon a board when they were going to employ an engineer, because it was liable to bring clashes between them. Of course we failed to see any reason in that, and said we did not know of any engineers on the railroads who had clashes with assistants, and we could see no occasion for clashes in this case. Where engineering subjects are treated in the East, the majority of those boards are engineers. They employ hundreds of engineers, and the work goes on to its final issue without any clashes whatever. The authority is vested in the board, and if the subordinate does not do his duty, he is asked to resign. When I was President of the Society I appealed personally to Governor Rickards, who was to appoint a Capital Site Commission, a Capital Building Com-

mission and the Arid Land Commission. I called upon him and stated that the engineers of the State did not think they were properly recognized in positions for which they had been specially trained. He admitted that he had been spoken to about the matter, and had given the matter some consideration, but that he had concluded it was better to appoint business men upon these commissions inasmuch as they would have to go forth and secure the money necessary to fulfill these objects. I asked him whether I was to consider that he regarded engineers as not being business men, and called his attention to the fact that my understanding of the training of an engineer was that his essential quality was to make an interest upon capital. I formed the impression subsequently that our illustrious Governor never made any appointments but for one purpose, and that for political ends, and I have since been sustained in that belief by many members of his own party. Politicians will not appoint engineers upon engineering commissions, or architects upon commission dealing in architecture, until we force them to it by exerting a political influence.

MR. CARROLL.—I agree with Governor Rickards in some of the views expressed by Mr. Keerl. I think that there is nothing more disagreeable to a chief engineer than to have on his Board of Directors an engineer. I believe that a chief engineer should have a voice in the directory if possible.

Never have an engineer on the board and a chief engineer besides. I should like very much to see the State Engineer made the chief engineer of the Arid Land Commission if it were possible, but I do not think it is. I think the same argument comes up in opposition to the bill to try to force him on this commission, and if he is a member of the commission he should be the chief engineer, otherwise he is only one of the board of three (or five?) and he is continually hampering the engineer in the discharge of his duties. This is not the case with the engineer of a railway company with his subordinates, because he looks to the directors.

MR. BLACKFORD.—If the Arid Land Commission chooses to employ the State Engineer as its engineer I think that it would be his duty to so act, but I do not believe it would be advisable to try to amend the Arid Land Grant bill by this bill, and make him an *ex-officio* member of that body, or their engineer.

Mr. Booth suggested that the Arid Land Commission can call at any time upon the State Engineer for any information required.

Mr. Williams, with the consent of his second, withdrew his motion.

On motion of Mr. Carroll, seconded by Mr. Williams, an amendment was adopted, providing that the Arid Land Commission shall have authority to call upon the State Engineer for such advice and professional services as they may require in the performance of their duties, and that the State Engineer shall perform such services without further compensation than the salary herein provided.

A few other amendments were made to the bill, which was then approved and handed to Hon. E. H. Wilson, member of the House of Representatives of the State of Montana, who will introduce the bill. Mr. Wilson will also introduce a bill establishing a standard of measurement for water, and defining the equivalent of a miner's inch. This bill is substantially the same as the bill drafted by A. M. Ryon (see page 87, No. 1, of Vol. XIV, 1895, of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES).

Since the Society, in its efforts to further needed legislation for the benefit of Montana, has devoted much time and labor to the advocacy of

the State Engineer bill it was considered desirable that said bill be published in full in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, and that the Society order reprints of same.

The bill as finally approved is as follows:

HOUSE BILL No. 28.

AN ACT creating the office of State Engineer, defining his duties and regulating his compensation.

Be it enacted by the Legislative Assembly of the State of Montana:

SECTION 1. As soon as practicable after the passage of this act there shall be appointed by the Governor a State Engineer, who shall hold his office for a term of four years, or until his successor is appointed and qualified.

No person shall be eligible to such office unless he shall have had at least ten years' experience in the actual practice of the profession of civil engineering, nor unless he has such theoretical knowledge and such practical experience and skill as shall fit him for the office.

The Governor may remove such State Engineer for cause, and in case of such removal, or in case of death or resignation, shall appoint a successor.

SEC. 2. The said State Engineer shall have his office at the State Capitol, in suitable rooms to be provided for him by the Secretary of State, who shall furnish him with suitable furniture, postage, and such proper and necessary stationery, books and instruments as are required to best enable him to discharge the duties of his office.

He shall be paid a salary of \$4000 per annum, payable monthly by the State Treasurer, upon warrants drawn by the State Auditor. He shall also be paid for his actual and necessary traveling expenses when away from his office on official duties.

SEC. 3. Before entering upon the duties of his office, said State Engineer shall take and subscribe an oath before some duly authorized officer, to faithfully perform the duties of his office, and shall file such oath with the Secretary of State. He shall also file with the Secretary of State an official bond in the penal sum of \$10,000, with not less than two sureties, to be approved by the Governor, and conditioned upon the faithful discharge of his duties, and for delivery to his successor of all notes, maps and records of his office, and all property belonging to the State then in his possession or under his control.

SEC. 4. Said State Engineer shall have power to employ, after obtaining the consent of the Governor, one or more assistant engineers of his own selection, and such instrument men and helpers as may be necessary to economically and properly perform the duties of his office, as hereafter defined. The salary of said assistant engineers shall not exceed \$150 per month each, and the actual traveling expenses of such assistant engineers and helpers while away from the permanent office of the State Engineer shall be defrayed by the State.

SEC. 5. The State Engineer shall make, or cause to be made, careful measurements of the flow in cubic feet per second of the various streams in the State whose waters are, or are likely to be, appropriated and used, commencing with those streams most used for irrigation. He shall collect facts and make surveys to ascertain suitable locations for reservoirs upon streams where such reservoirs may be possible and beneficial, and shall, as far as practicable, determine the cost of constructing such reservoirs, and obtain all other facts in regard to quantity of water possible to be stored, the character and extent of land that may be reclaimed by the water from such reservoirs, together with all other information bearing upon the subject. He shall make himself familiar with the waterways and the irrigable land of the State, and the needs of the State as to irrigation matters, and all records of such information shall be the property of the State, and open to public inspection. He shall keep full and complete records of all measurements of streams, surveys, examinations or other valuable information that may come into his possession concerning any of the duties of his

office, and shall furnish reasonable information in regard to such measurements or surveys to the newspapers of the State upon proper request.

SEC. 6. Any person, association or corporation who shall desire to construct any dam or dyke more than ten feet in height, for the purpose of storing, appropriating or diverting any of the waters of this State, except as otherwise in this act provided, shall submit duplicate plans, drawings and specifications of the proposed work to the State Engineer, who shall as speedily as possible and within fifteen days, examine such plans, drawings and specifications, and, if he approve them, he shall affix his approval thereto, and return one copy of each such plan, drawing or specification, with his approval, to the party or parties proposing to construct the works. If the State Engineer shall disapprove of such plans, drawings or specifications, he shall return the same with his written objections thereto and suggestions of changes to the party or parties filing the same; Provided, Where said dam or dyke is, in the opinion of said engineer, not of sufficient importance to have the provisions of this section apply, then said engineer shall have power, upon written application, to suspend the provisions of this section in regard to such dam or dyke.

SEC. 7. In cases of great importance, especially where life or property would be endangered by the failure of such works, the State Engineer may require excavations to be made to determine the character of the foundation, and require a statement of the facts in the case to be filed in his office before approving such plans, drawings or specifications, or he may, if he deems the public interest demands, visit the locality of such proposed works before the approval of said plans, drawings or specifications, and supervise the construction of the same; and no rights of any kind under the laws of this State shall be deemed to be obtained where the proposed works, as in this section provided, have not been approved by the State Engineer.

SEC. 8. Whenever any party or parties feel themselves aggrieved by the determination of the State Engineer in refusing to approve any plan or specification, as mentioned in the preceding section, then such party or parties may have an appeal to the courts.

SEC. 9. The State Engineer shall inspect, or cause to be inspected, as often as he thinks advisable, every dam or embankment used for holding water in this State, where the same is more than ten feet in height; and if, after any such inspection, such dam or embankment, in the opinion of the State Engineer, is unsafe, and life or property likely to be endangered by reason thereof, he shall order the owner or owners to repair the same, so as to make it safe. If such owner or owners shall neglect or refuse to repair the same within three days after notice to that effect has been given in writing by the State Engineer, then said State Engineer shall report the facts in the case to the Judge of the District Court of the district in which such dam or embankment is situated, who shall, after hearing such facts, if he deem it necessary for the public welfare, order the Sheriff of the county to draw off such water from behind such dam or embankment, and to keep said water drawn off until such time as the orders of the State Engineer shall have been complied with.

SEC. 10. If any person or persons shall report in writing to the State Engineer that any dam or embankment used for holding water is unsafe and dangerous to life or property, then it shall be the duty of said State Engineer to inspect, or cause to be inspected, such dam or embankment as soon as practicable, and, if he considers it unsafe, he shall proceed as provided in Section 9 of this act.

SEC. 11. The State Engineer shall, free of charge, give any information desired by any person as to the proper method of measuring water, or of constructing an apparatus for such measurement.

SEC. 12. The State Engineer may require, and shall receive from the Attorney-General of the State, legal advice upon any question of public interest arising in the performance of his duties under this act, which advice shall be in writing when so desired by said engineer.

SEC. 13. The State Engineer shall make and render to the Governor bi-annually, or oftener if required, a full and true report of the work performed by virtue of his office, which report shall contain any recommendations he may have to make regarding legislation, affecting his office, or

the irrigation laws of the State, or other matters of public interest which his experience and information may suggest.

SEC. 14. In addition to the duties prescribed in the previous sections of this act, the State Engineer shall perform such professional duties as may be required of him by the Governor, and he shall give advice on any matter of a professional nature when called upon by the Governor so to do.

SEC. 15. The Arid Land Commission shall have authority to call upon the State Engineer for such advice and professional services as they may require in the performance of their duties, and the State Engineer shall perform such services without further compensation than the salary herein provided.

SEC. 16. All acts and parts of acts in conflict herewith are hereby repealed.

SEC. 17. This act shall be in full force and effect from and after its passage and approval.

The Secretary reported no unfinished business.

Under the head of new business the Secretary read a communication from R. H. Chapman in regard to taking steps toward establishing a Department of Mines and Mining in connection with the United States Geological Survey.

MR. WILSON.—I move that it is the sense of the Society that this addition to the Geological Survey is a very desirable one for the mining interests of Montana, and that our Senators and Representatives in Congress be advised of such resolution, and urged to give their support to the measure; and that it be drawn up in like form with the resolution presented by Mr. Chapman.

It was moved by Mr. Booth that the Society request the President and Secretary to write to each of the Representatives of this State in Congress, asking them to use their endeavors to have this bill passed. Seconded by Mr. Wilson and carried.

No further business being presented, the meeting adjourned.

On January 13 the members visited Canyon Ferry Dam (see "Canyon Ferry Dam," Vol. XX, 1898, page 331, May number of JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES). Superintendent M. H. Gerry took especial pains to show the visitors around and explain the construction and works. The change being made in the apron of the dam was of particular interest, the present being an inclined apron. As originally designed and constructed, the spillway portion of the dam was a series of steps, and proper allowance was not made for high water upon the spillway. The width of these steps not being sufficient, a defect which came very near causing the destruction of the dam when the first high water came, the water struck at the extreme outer edge of the first step, and from there had a clear drop to the outer edge of the lower step, the force being sufficient to wash out the lower step in a short time, and to soon make a large excavation, the dam settling and springing out of line from 4 to 5 feet.

At 8.30 P.M. the members and invited guests, consisting of members of the Legislature and many citizens of Helena, gathered at an entertainment in the Chamber of Commerce rooms. The entertainment was enlivened by music by the Helena Military Band, and singing with piano accompaniment. President Page was escorted to the chair and a number of short speeches were delivered. Among the speakers were Hon. E. D. Weed, Speaker Stiff, of the House of Representatives; Messrs. E. H. Wilson, C. W. Goodale and Donald Bradford, of the Arid Land Commission; Judge Stevens, of Missoula, and Messrs. Bruffy and More.

On January 14 the members visited the Peck Concentrator, three miles from Helena. Superintendent F. W. Rossberg escorted the members through the works and explained their operations. The Peck Concentrator is original in design, and entirely dissimilar, in its methods of operation, from all other concentrators.

Returning to Helena, the regular annual meeting was called to order at 3 P.M. by President James M. Page. The minutes of the preceding meeting were read, applications for membership from Carlisle Mason, William H. Harrison, Charles D. Vail, Charles H. Repath and John D. McLeod were presented and favorably considered, and the Secretary was directed to send out the usual letter ballots.

Messrs. Finlay McRae and Wm. H. Williams were appointed tellers to canvass the ballots for officers. The officers elected were:

Eugene Carroll, President; Maurice S. Parker, First Vice-President; Frank L. Sizer, Second Vice-President; Albert S. Hovey, Secretary and Librarian; Forrest J. Smith, Treasurer; James S. Keerl, member of Board of Managers of the Association of Engineering Societies; Finlay McRae, Trustee for three years.

Upon the announcement of the result of the ballot President Page said: "Members of the Society, by your ballots you have elected Mr. Carroll the President of this Society for the coming year. I will appoint Mr. Blackford and Mr. Bickel to escort the President-elect to the chair. Mr. Carroll, it is with much pleasure that I congratulate you upon your election to the office of President of this Society. Gentlemen, I present to you your President for the ensuing year, and in retiring I beg again to thank you for the honors you have conferred upon me during the past year."

Upon taking the chair Mr. Carroll said: "Gentlemen of the Montana Society of Engineers, by your votes you have given me one of the most honorable positions which it is in your power as members of this Society to bestow upon any member, and I assure you that I appreciate the honor. I have always taken a great interest in societies of this character. As soon as I had left school and started in my profession, I joined the American Society of Civil Engineers as junior, and I have stepped up from junior until now I am a full member.

"I am a charter member of the Cincinnati Club of Engineers and of the Cincinnati Association of the American Society, and after I became associated with you engineers in Montana and made my home here, I immediately applied and was elected a member of this Society. When I joined the Society it had a small membership, but an enthusiastic one. At the present time the membership of the Society is such that we are established as a power in the State, and of great benefit to our members. There are still further chances for the Montana Society, and I hope within the next few years to see the membership more than doubled. There are several ways in which this can be done, but no better way than for each individual member of the Society to make himself a soliciting committee to bring in the engineers of the State. At present, most of the older engineers are members of this Society, but there are many young men scattered over the State who, with a little solicitation, would join, and if we should make it attractive to them our membership would vastly increase in very short order.

"One method which has presented itself to me, and which I have dis-

cussed with several members of the Society during the past year, is the holding of the monthly meetings at different parts of the State. For instance, in the Society five or six years ago, the majority of the members were from Helena. At the present time the majority are from Butte, and in Butte we have a very large field of young men and they should be induced to come into the Society. The benefits derived by the younger members of the profession from association in a Society of this class need hardly be enumerated. Under the present system the monthly meetings are all held in Helena, which is a long distance from many members in other parts of the State, so that the young men have not the time and cannot always afford to attend them. I should like to see more papers presented to the Society for discussion through the year. In the past, papers have been put off until the annual meeting, and there is so much business of importance to be transacted at that meeting that the papers fail to receive proper consideration and discussion. It would be much better if the papers were presented at the monthly meetings, and, say, every other meeting in Butte.

"In our Society in Cincinnati we had a hard time to start. We had only a very slim attendance at the meetings for a long while. Finally some practical member proposed that a lunch be provided at the meetings. It immediately increased the membership and made it a social gathering. I believe if we can hold these monthly meetings in a place where we have a large membership, we can introduce some such feature as that.

"Another device for increasing the interest in the Society was called the 'Question Box.' Any member could send to the Secretary a question or a number of questions, which were put in the question box, and once or twice a month the question box was opened. This brought up a great variety of subjects, which were discussed among the engineers at the meeting. I am pleased to say that the Cincinnati Society has joined the Association of Engineering Societies, and is in good condition as to finance and as to membership also.

"I again thank you for the honor conferred upon me, and I hope that each and every one will co-operate with me to make 1899 the banner year for the Montana Society of Engineers."

First Vice-President Maurice S. Parker was not present to take his chair.

Second Vice-President Frank L. Sizer, upon being introduced, spoke as follows:

"Gentlemen, I want to indorse Mr. Carroll's suggestion about distributing these monthly meetings. I thank you, gentlemen, for the honor conferred in my election."

The Secretary, being called upon for a speech, replied:

"Gentlemen, I believe a speech is never expected from the Secretary, so please excuse me. But I wish to thank you for this and previous honors."

Forrest J. Smith, Treasurer, spoke as follows:

"President and Members, all I can say is that I was Secretary long enough to become pretty well acquainted with most of the members, and I thank you for this honor."

Finlay McRae, upon being introduced, responded as follows:

"Mr. President and Members of the Society, I do not know whether to thank you or not for putting me back in harness, but I will try, to the

best of my ability, to fulfill the duties of a Trustee of this Society in conjunction with my two colleagues. I thank you for the honor."

REPORTS OF STANDING AND SPECIAL COMMITTEES.

MR. WILSON.—The cost of this meeting will be in the neighborhood of \$200. I will leave it to the Society to arrange the means by which that expense will be promptly met.

Upon suggestion of the President, Mr. Carroll, Mr. Wilson moved that the members of the Society present be requested to pay \$3.50 each for the expenses incurred. Motion carried.

Under the head of new business, Mr. McRae moved that the President appoint a committee of three to look into the matter of changing the headquarters of the Society, and to report upon same at the next monthly meeting on February 11. Motion carried.

The President appointed the following committee: Mr. Wilson, of Butte; Mr. Hovey, of Helena; Mr. Goodale, of Great Falls.

Mr. Goodale offered the following resolutions:

Resolved, That the thanks of this Society are due to the following persons for courtesies extended to the Society at this annual meeting, and that the Secretary be instructed to notify these persons of the appreciation of the Society: To the Committee of Arrangements, to Mayor Edwards, of the city of Helena; to N. G. Miller, Chief Engineer of the Great Northern Railway; to Mr. Kendrick, Vice-President of the Northern Pacific Railway; to Mr. P. J. Tuohy, to Superintendents M. H. Gerry and Whitley, to Mr. S. T. Hauser, to Messrs. Parker, Williams, Page and Carroll for papers which we will hear later on, to Mr. N. Kessler for his kind invitation extended to the Society to visit the tile and sewer pipe works, which, however, the Society was unable to visit.

Motion carried.

President James M. Page then delivered his retiring address, after which Prof. Wm. H. Williams delivered the following address:

ENGINEERING WORK AT THE MONTANA STATE COLLEGE.

Probably few persons in Montana realize what is being done for engineering education in the various State educational institutions. Take as an example the State Technical School,—the Montana State College. This institution now offers four-year courses in mechanical and electrical engineering, which will be found by comparison to be practically equivalent to similar courses offered in Eastern universities; and, what is more, it has the equipment with which to make these courses mean something.

Modern educational methods demand laboratories for instruction and research, and, thanks to the generosity of the Federal Government, this college has been well provided with funds for the purchase of such equipment, and now has well-equipped chemical, physical, biological and engineering laboratories and shops. In every department of instruction theory and practice go hand in hand. The student listens to lectures in physics, chemistry, biology or engineering in the morning, and in the afternoon goes into the respective laboratories for practical instruction along the lines of the previous theoretical work. I venture to say that these laboratories are fully equal in quality and character of apparatus to similar ones provided for undergraduate work in any Eastern universities. The engineering laboratory and shops, for example, now represent an expenditure, exclusive of buildings, of \$16,000.

A brief outline of the engineering equipment and practical work may be interesting. In addition to the mathematics, chemistry, language and history of the freshman year, eight hours per week are spent in shop practice in woodwork,—the first half of the year on carpentry, for which provision has been made for twenty-six students, each one having his own set of tools, for which he can be held responsible. The last half of the year is devoted to wood turning and pattern making, in which sixteen students can be accommodated. The shop practice for the first half of the sophomore year is forge work. The forge shop is equipped with ten down draft forges, and all necessary tools for each, including power blower and exhausters; and at the present time these are all in use three afternoons per week. The last half of this year's shop practice is devoted to chipping and filing and lathe work. The junior year shop practice is devoted to drill, lathe, planer and milling machine work, including work in cast iron, wrought iron, gear cutting, etc. The senior year's work is in the construction of some complete machine called the "Senior Model."

The equipment for machine work consists of five lathes, a planer, a milling machine, a shaper, three drills, a tool grinder, a small universal grinding machine and shop saw. The shop building is lighted with electricity from a small dynamo driven from the head shaft, and has in it also an office, tool room, toilet and locker room and boiler room.

Turning now to the engineering laboratory, the juniors and seniors have, for work in steam engineering, an eighty-five horse power boiler with a full outfit of scales, tanks gauges, calorimeters, draft gauges, etc., for boiler trials; four steam engines, one of fifteen, one of forty, and one of sixty horse power, and a threshing engine, three indicator sets, speed counters, tachometers; gauges, calorimeters and brakes for engine trials. The forty horse power engine is especially designed for experimental work, and can be used with a live or exhaust steam jacket, or unjacketed.

For work on the strength of materials there is a Riehlé automatic and autographic testing machine of 100,000 pounds capacity, and an Olson torsion testing machine having a capacity of 50,000 inch pounds, and taking a specimen as large as $1\frac{1}{2}$ inches by 5 feet.

The Riehlé machine is a very fine one, and is the only one of that size owned by any educational institution west of the Mississippi. This machine will take steel specimens up to 1 inch in diameter, and traces its own stress-strain diagram.

The electrical equipment is only about half completed at present, and now consists of a 6 K-W bipolar dynamo, two specially designed multipolar dynamos of 15 K-W each, so arranged as to give direct, or one, two or three phase alternating currents; an arc lighting dynamo and outfit of typical arc lamps, besides a goodly number of ammeters, volt-meters and watt-meters.

This equipment will be liberally increased this year. For the more refined electrical measurements the physical laboratory has a good equipment of electrical test instruments.

This brief outline will show how well the institution is equipped for thorough work along engineering lines. A course in chemistry is also offered, and here, too, the equipment is all that can be desired.

A course in mining engineering is not offered, because the state has made provision for the separate college of mining engineering, but any student can, by taking a combination of the mechanical engineering and

chemical courses, get a mining engineering course that is very nearly equal to the straight mining engineering courses offered in other institutions.

The meeting then adjourned until 8 P.M.

Meeting called to order at 8 P.M.; President Carroll in the chair. Mr. Bradford brought up the subject of pumps and irrigation. It was generally agreed that the centrifugal pump was the best for irrigation, but that pumping water for irrigating farms was a losing business, although it perhaps would pay for gardening.

In reply to a question with regard to keeping canals open in winter, Mr. Carroll stated that his experience had been that when the first heavy frost comes before the first heavy snow, the top of the stream freezes over, leaving a passage which carries water quite a long time, and that the canal can be kept running all winter. Other members stated that the Dillon, Bozeman and Livingston canals were running during the winter.

The subject of slush ice was brought up.

Mr. Goodale, referring to the Great Falls dam, stated that sometimes they had to stop and dig the ice out.

MR. BRADFORD.—I have been told they made mats of brush, which catch the slush ice and freeze it, so that the water passes underneath.

MR. CARROLL.—I believe that in this climate a covered canal can be run successfully. I would cover it with a regular floor. They never have had any trouble with Daly's flume to the smelters. When we were building our present dam and storage reservoir, we had to deliver water to the city at the same time, and I built a small temporary dam above the main structure, and took the water right out in a flume. All I had was a grating to keep floating ice from getting into the flume. By placing the penstock below the surface, trouble with ice is avoided.

MR. BRADFORD.—How do you account for ice forming on the bottom?

MR. KINNEY.—The same thing happens in the reservoirs where they are shallow. The anchor ice will stick to the bottom.

MR. GOODALE.—The broken or slush ice passes through the larger wheels. To obviate difficulty at Great Falls, we have a canal which we keep open in cold weather, and which carries the ice down under the ice formed in the river above. Being thus conducted, the ice rises to the surface and is carried over the falls.

MR. CARROLL.—From my observations there is no trouble with slush ice within five feet of the surface.

MR. BRADFORD.—When the ice rots does it sink?

MR. CARROLL.—It sinks below the surface, but does not go to the bottom.

MR. BOOTH.—A gentleman in charge at Canyon Ferry said all their ice stopped at the head of the canyon, and they were not bothered with it down at the power house.

MR. BICKEL.—I think if the head of the canal is built properly there is no occasion for the ice to stop there. Generally the dam comes out almost parallel with the river, instead of coming out at right angles. The current going by causes an eddy there, and the ice turns right into the canal as a rule.

MR. CARROLL.—I think it would be well to build a good, heavy screen, so that the ice, coming down in the river, would be shot away from the canal. In a small ditch a heavy iron screen could be made to keep out

the small particles of floating ice or driftwood. I hardly think small water-growth or *débris* would stop it up.

MR. BRADFORD.—In the Dearborn canal I put in a very heavy wire fish-screen to keep the fish from getting through, and we had to take it off frequently.

MR. CARROLL.—The water may be clear as crystal, and yet on the screens a vegetable matter gathers that smells "fishy."

MR. SIZER.—In ordinary cool weather perhaps, say in the earlier part of the winter, there is a very noticeable and disagreeable brackish taste.

MR. CARROLL.—The water in the reservoirs purifies itself. Cleaning the bottom of reservoirs has been tried. They have spent in Boston much money in endeavoring to solve the problem, and I think something like seven per cent. of the cost of the reservoir is spent in cleaning the bottom. We cleaned our reservoir very carefully, but it spoiled this year.

Mr. Bradford brought up the subject of arched steel dams.

MR. CARROLL.—In California they are building an irrigation dam in which the core wall is made with a steel sheeting surrounded by concrete. These steel plates are riveted and calked and then 6 inches of concrete is placed on each side. The concrete is not for strength, but to make it watertight. I think it is a rock-filled dam. Settlement might produce cracks in the concrete, but not in the plate. The proposition of building dams out in this country is a very serious one, from the fact that our material and labor are so costly that masonry dams are almost barred. I have been quite interested in watching the development of these steel dams, which, by the way, Mr. Bradford can tell you something about.

MR. BRADFORD.—Some six or seven years ago I conceived the idea of building arched steel dams, and I submitted the idea to a representative of Cooper, Hewitt & Co., who said he never heard of it before, but that he thought it was perfectly feasible. The arches were to be built convex upstream, and to be faced with timbers. He submitted the idea to the Engineering Society of Chicago, and wrote me that they all said it was perfectly feasible. Afterwards he told that in California a 100-foot dam so built cost only a hundred thousand dollars.

Mr. Page then gave an interesting description of the construction of the Lima dam, its shortcomings, etc., and Mr. Wilson also described the failure of the drainage canal of the Bimetallic Company. Both failures were due to poor engineering, and resulted in the loss of property. In regard to the Lima dam, Mr. Page stated that if the tunnel, in connection with the dam, had been properly lined, and an adequate spillway provided, no failure would have occurred. In the case of the Bimetallic, the failure was due to amateur engineering, the regular engineer having been discharged, and no doubt this finally resulted in the failure of the Bimetallic Company.

Mr. Goodale moved that 250 copies of the proceedings of the twelfth annual meeting be published. Carried.

MR. HOVEY.—We have one patriot in our Society, Mr. Ripley, who is now serving his country at Manila. The pay of the army is not very large, and I think Mr. Ripley should not be assessed for dues for this year.

MR. SIZER.—I move that Mr. T. M. Ripley's dues be remitted for the current year of 1899, and that the Secretary be ordered to notify him that this action has been taken. Motion carried.

No further business appearing, the meeting then adjourned.

A. S. HOVEY, *Secretary*.

A SPECIAL meeting was held in the art room of the Butte Public Library, Butte, Montana, on March 11, 1899.

Meeting called to order by President Eugene Carroll at 8.30 P.M., Mr. James S. B. Hollinshead acting as Secretary *pro tem*.

Twenty members and three visitors were present. The minutes of the preceding meeting in Helena were read and approved. The applicants for membership were Lewis C. Parker, of Garnet, Mont., and C. V. Page, of Butte, Mont. Messrs. Winfield J. Flood and Wm. Zeschke, both of Butte, were elected members. An amendment to Article V of the by-laws was introduced, to be acted upon at the next meeting. The Secretary was instructed to have a "List of Members" of the Society printed.

A letter from J. C. Trautwine, Jr., Secretary of Association of Engineering Societies, in regard to allowing Societies ninety per cent. on advertising secured by them for the JOURNAL, was read. A letter from Mr. John F. Davies, Librarian of the Butte Public Library, was read, in which the Trustees of said Library presented to the Society the use of the art room for meetings, and shelf room for Society's library. A vote of thanks was extended to the Trustees of the Library for this courtesy; also to Mr. E. H. Wilson for his energetic endeavors, in the Sixth Legislative Assembly, to pass the bills providing for the measurement of water, and the establishment of the office of State Engineer. The Society was much encouraged by the passage of the following bill:

HOUSE BILL No. 29.

Introduced by E. H. Wilson.

A BILL FOR

AN ACT Establishing a Standard of Measurement for Water, Defining the Equivalent of a Miner's Inch, and Repealing Section 1893, Title VIII, Part IV, Division II, of the Civil Code of the State of Montana, and all conflicting Laws.

Be it enacted by the Legislative Assembly of the State of Montana:

SECTION 1. Hereafter a cubic foot of water (7.48 gallons) per second of time shall be the legal standard for the measurement of water in this State.

SEC. 2. Where water rights expressed in miners' inches have been granted, one hundred miners' inches shall be considered equivalent to a flow of two and one-half cubic feet (18.7 gallons) per second; two hundred miners' inches shall be considered equivalent to a flow of five cubic feet (37.4 gallons) per second, and this proportion shall be observed in determining the equivalent flow represented by any number of miners' inches.

SEC. 3. Provided, that the provisions of this bill shall not affect or change the measurement of water heretofore decreed by a court, but such decreed waters shall be measured according to the law in force at the time such decree was made and entered.

SEC. 4. Section 1893, Title VIII, Part IV, Division II, of the Civil Code of the State of Montana, and any laws in conflict with this act, are hereby repealed.

Approved March 3, 1899.

ROBERT B. SMITH, *Governor*.

Prof. A. M. Ryon, by numerous experiments at the State Experiment Station, determined the equivalent of a miner's inch, given in the above bill. (See Measurement of Water, JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, Vol. XIV, January, 1895.)

Mr. F. W. Blackburn, ex-City Engineer of Butte, read a paper on "Development of Roads and Street Pavements," followed by a paper from

Clar. W. Swearingen, City Engineer of Great Falls, relative to "Experience in Paving in Great Falls." In the discussion which followed, the members generally agreed with Mr. Blackford that properly constructed wooden blocks and asphalt pavings were the best under the most trying conditions. A vote of thanks was tendered for the interesting papers, whereupon the meeting adjourned.

A. S. HOVEY, *Secretary*.

Engineers' Club of Cincinnati.

CINCINNATI, OHIO, FEBRUARY 16, 1899.—103d regular meeting. Beginning with this meeting the new arrangement of assembling for dinner at an early hour was inaugurated.

Twenty-three members and visitors were present for dinner, which was served at 6.10 P.M.

The meeting for regular order of business was called to order at 7.10 P.M. with President Hazard in the chair.

There were twenty-two members and six visitors present.

Minutes of the meeting of January 19 were read and approved.

Applications for active membership were received from Mr. Allan Cox and Mr. Alfred Frank.

On ballot being taken Mr. Hadley Baldwin was elected to active membership.

Mr. G. B. Nicholson, for the Committee on Memoirs, presented a short sketch of the life of Israel Ludlow, the pioneer surveyor of Ohio, who in 1789 surveyed the original town plot of Cincinnati, and those of Hamilton and Dayton a few years later, besides other work for the United States Government in this vicinity. This was ordered received and entered on the records of the Club.

The President advised the Club that the matter of joining the Association of Engineering Societies had been consummated.

Mr. M. D. Burke read the paper for the evening, on "Street Railway Track Construction." The paper was quite fully discussed by Messrs. Read, Punshon, Stanley, Innes, Rabbe, Hazard, Wulff, Elzner, Meeds and Burke.

Adjourned.

J. F. WILSON, *Secretary*.

104TH REGULAR MEETING, CINCINNATI, O., MARCH 16, 1899.—Dinner was served at 6.15 P.M.

Regular meeting called to order at 7.20 P.M.; President Hazard in the chair and twenty members present.

Minutes of the meeting of February 16 were read and approved.

Applications for active membership were received from Messrs. L. A. Rose, Supervisor of Track C., C. and St. L. Ry., Cincinnati Div.; C. L. Parmelee, Chief Engineer Continental Filter Company, New York city; Wm. E. Gunn, Asst. Engr. on reconstruction of Covington and Cincinnati suspension bridge, and Chas. A. Knowlton and John A. Hiller, Asst. Engrs. on construction of new water works for Cincinnati at California, O.

Messrs. Allan Cox and Alfred Frank were elected to active membership.

The Secretary announced the death of Fred. C. Weir, President of the Weir Frog Company. Mr. G. B. Nicholson was appointed a committee to prepare a suitable memoir of Mr. Weir.

The paper for the evening was read by Mr. James M. Harper, on "The Liberty Street Tunnel and Sewer." The part of the sewer referred to in the paper was constructed in 1868-9, and was composed of four rings of hard-burned hand-made sewer brick, the inside diameter being 9 feet 6 inches. Louisville cement was used.

In 1878, eight years after the sewer was put in service, the bottom was found to be in very bad condition. For a lateral distance of 2 or 3 feet in the invert the bricks had been abraded to such an extent that the first course and a considerable part of the second course were entirely gone, the third course even showing wear in places.

Repairs were made by putting in limestone blocks about 4 feet long, 12 inches wide and 8 inches thick. These were dressed on all sides except the bottom, and were laid in pairs with joint in the center line of the sewer. Later this construction was changed and single blocks were laid 20 inches to 24 inches wide and only 4 inches thick.

In 1898 an examination showed that the 4-inch blocks were almost entirely worn out, holes being worn in places through the stones and about 4 inches worn from the 8-inch stones, and the joints between them worn in a "V" shape nearly to the bottom. Repairs are now being made by filling these joints with a quick-setting cement and replacing the 4-inch blocks with vitrified brick.

Specimens of the old stone and brick from the tunnel were exhibited, showing the peculiar manner in which they had been worn away.

Adjourned.

J. F. WILSON, *Secretary*.

Boston Society of Civil Engineers.

BOSTON, MASS., FEBRUARY 15, 1899.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8.10 o'clock P.M.; Vice-President C. Frank Allen in the chair. Sixty-six members and visitors present.

The record of the last meeting was read and approved.

Messrs. Leonard H. Davis, Guy C. Emerson, Robert R. Evans and James Rice were elected to membership.

The chair announced that the President had appointed Messrs. Chas. H. Swan and Edmund S. Davis as the tellers to canvass the ballots for officers at the annual meeting on March 15.

The Secretary read a communication from the Austrian Society of Engineers and Architects, inviting this Society to be present at the exercises to be held at Vienna on March 18, commemorative of the 50th anniversary of the organization of that Society. On motion, the letter was referred to the President for a suitable acknowledgment, on behalf of the Society.

The literary exercises consisted of a talk by Mr. George S. Rice on "Grouting of Defective Work on the New Croton Aqueduct." Mr. Rice gave a very interesting account of the building of the new aqueduct and of the methods employed to discover the defective portions of the work. He then described very fully the work of grouting above the crown of the arch. The description was illustrated by a large number of lantern views.

Adjourned.

S. E. TINKHAM, *Secretary*.

Engineers' Club of St. Louis.

486TH MEETING, MARCH 1, 1899.—Meeting was called to order at 8.20 P.M.; President Colby in the chair. Thirty-one members and six visitors were present. The name of Mr. R. H. Phillips was proposed for membership. The names of Messrs. V. K. Hendricks, F. F. Axtell, H. B. Shaw and W. A. Bennett, having been recommended by the Executive Committee, were balloted for and all declared elected members of the Club.

Col. E. J. Spencer then read the paper of the evening, entitled "World's Fairs." The histories of previous expositions, international in their character, were briefly gone over, and mention made of some of their main features. The cost, financial success and attendance of all these were given, and some comparisons made, showing the relative sizes. The growth of electric lighting was traced through the later fairs.

A large number of lantern slides were shown, illustrating the various architectural and engineering features of the Paris, 1889; Columbian, 1893, and Omaha, 1898, Expositions.

Some interesting statistics of the number of people attending the Paris Exposition, and the estimated amount of money which the visitors brought, were read.

A few questions were asked, and Mr. Julius Pitzman made some remarks on the prospective Louisiana Purchase Exposition, giving the reasons for holding it and explaining what special legislation is necessary to successfully accomplish it. He also said that it was highly important to make it entirely different from the Chicago Fair, and suggested that the members try to devise some novel idea for it.

There being no further business, the meeting adjourned to another room, where lunch was served.

E. R. FISH, *Secretary*.

487TH MEETING, MARCH 15, 1899.—The meeting was called to order at 8.20 P.M. by President Colby. Eighteen members and one visitor were present. The minutes of the 486th meeting were read and approved. The minutes of the 271st meeting of the Executive Committee were read. The name of Mr. Hiram Phillips was proposed for membership, and the name of Mr. R. H. Phillips, having been recommended by the Executive Committee, was balloted for and declared elected a member of the Club. Plans for the celebration of the 30th anniversary of the Club were discussed. Details of arrangements to be left to the Entertainment Committee.

The paper of the evening, "Recent Concrete Construction on the Illinois and Mississippi Canal," was then read by the Secretary, in the absence of the author, Mr. J. W. Woermann. The paper gave a description of the methods of construction of the locks being constructed on the canal, and the proportions and character of the materials used. Costs of the various items making up the total cost of two of the locks were given and comparisons made of their cost per cubic yard on this work with the cost of similar work in other parts of the country. Some drawings and photographs showing the details of construction were exhibited. The discussion was participated in by Messrs. Ferguson, Dean, Colby, McMath and Ockerson. There being no further business, the Club adjourned to another room, where lunch was served.

E. R. FISH, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR MEETING, MARCH 3, 1899.—Called to order at 8.30 P.M. by President Percy.

The minutes of the last regular meeting were read and approved. The following were elected by ballot: Members—E. M. Fraser, mechanical engineer; A. Ballantyne, engineer, U. S. Light House Department; F. C. Herrmann, civil engineer. Associates—Thomas W. Butcher, builder; Daniel McPhee, builder; Frank H. Masow, builder; John D. McGilvray, builder; Chas. A. Day, builder.

The following applications were made and referred to the Board of Directors: For members—Geo. N. Randle, assistant engineer, Board of Public Works, Sacramento, Cal., proposed by C. E. Grunsky, D. E. Hughes and Otto von Geldern; W. C. Elsemore, City Engineer of Eureka, Cal., proposed by D. E. Hughes, C. D. Marx and Otto von Geldern; Walter de Buxton, assistant engineer, S. Fe. P. R. R. Co., Williams, Arizona, proposed by Louis Falkenau, G. W. Percy and Otto von Geldern; H. A. Brigham, mining engineer, of San Francisco, proposed by C. E. Grunsky, H. C. Behr and Otto von Geldern. For associates—F. E. Knowles, builder, San Francisco, proposed by G. W. Percy, Hermann Barth and E. T. Schild; J. W. Miller, builder, San Francisco, proposed by G. W. Percy, Hermann Barth and Thos. W. Brooks.

The President referred to the Society's proposed visit to the battleship "Iowa," and, upon discussing the subject, the Secretary was instructed to circulate notices to members, stating the details of the intended trip, and asking all who desire to participate to inform the Society.

The Secretary was made a committee of one to perfect the necessary arrangements for the visit to the ship.

President Percy read a paper, entitled "Mechanical Influences in Architecture," which was discussed by a number of members present.

Adjourned.

OTTO VON GELDERN, *Secretary*.

Detroit Engineering Society.

THE 38th regular meeting of the Society was held in the smaller lecture room of the Detroit Art Museum, Friday, March 24, 1899. President Geo. Y. Wisner presided. There were about one hundred and ten members and guests, including many ladies, present.

The paper of the evening, "Locks and Lock-gates for Ship Canals," was read by the author, Mr. Henry Goldmark. It was illustrated by eighteen lantern slides made mainly from photographs of the locks at Sault Ste. Marie, Mich.

Adjourned.

A SPECIAL meeting of the Society was held at the Hotel St. Claire, Friday, April 7, 1899. First Vice-President W. J. Keep presided. Mr. W. C. King was elected to resident membership. The evening was devoted to a discussion on "Locks and Lock-gates for Ship Canals." It was opened by Mr. Henry Goldmark and participated in by Messrs. Woodard, Dunlap, Himes, Pope, E. Molitor, D. Molitor and Russel.

Adjourned.

HENRY GOLDMARK, *Secretary*.

ASSOCIATION OF ENGINEERING SOCIETIES.

VOL. XXII.

APRIL, 1899.

No. 4.

PROCEEDINGS.

Boston Society of Civil Engineers.

ANNUAL MEETING, MARCH 15, 1899.—The annual meeting of the Boston Society of Civil Engineers was held in Chipman Hall, Tremont Temple, Boston, at 7.45 o'clock P.M.; Vice-president C. Frank Allen in the chair. Eighty-two members and visitors present.

The record of the last meeting was read and approved.

Messrs. Walter A. Gleason, Channing Howard, Harry F. Macomber and Robert W. Pratt, Jr., were elected members of the Society.

The death of Charles E. C. Breck, a member of the Society, was announced, and, on motion, the President was requested to appoint a committee to prepare a memoir.

The thanks of the Society were voted to Mr. Herbert Tate, President of the City Refuse Utilization Company, for courtesies shown the members who took part in the excursion this afternoon.

The annual report of the Board of Government was read by the chairman, and by vote it was accepted.

The Secretary and the Treasurer each presented his annual report, and by vote they were accepted.

The report of the Committee on Excursions was presented by Mr. Metcalf, and by vote it was accepted.

The Librarian presented the report of the Committee on the Library, and by vote it was accepted.

Mr. FitzGerald, for the Committee on Quarters, submitted a brief report, which was accepted.

On motion of Mr. Stearns, it was voted that the question of continuing the several special committees of the Society, and the selection of the members thereof, and the question of printing the various reports which have been received this evening, be referred to the Board of Government with full powers.

On motion of Mr. FitzGerald, it was voted that the Board of Government be authorized to take any action necessary in the matter of renewing the leases or making a new lease with the Tremont Temple Baptist Church, with the New England Water Works Association and with the Hersey Manufacturing Company, or other desirable leases, and that the President and Treasurer be authorized to sign such leases on behalf of the Society.

On motion of Mr. Fales, the Board of Government was authorized to expend a sum not exceeding \$50 for standard engineering books for the Society's library.

Mr. Otis F. Clapp then gave a very interesting and entertaining account of the construction of the sewage pumping station and the precipitation tanks at Providence, R. I. The description was very clearly illustrated by lantern slides.

Messrs. Chas. H. Swan and Edmund S. Davis, the tellers of the election, submitted the result of the letter ballot for officers. There being no election for President, Vice-President and Director by letter ballot, the meeting proceeded to choose from the two candidates for each office having the highest number of letter ballots.

The President announced, as the result of the balloting, the election of the following officers:

President—C. Frank Allen.

Vice-President (for two years)—T. Howard Barnes.

Secretary—S. Everett Tinkham.

Treasurer—Edward W. Howe.

Librarian—Frank L. Fales.

Director (for two years)—Alfred E. Burton.

Adjourned.

S. E. TINKHAM, *Secretary*.

ANNUAL REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1898-99.

BOSTON, MASS., March 15, 1899.

To the Members of the Boston Society of Civil Engineers:

In compliance with the provisions of the Constitution, the Board of Government submits its report for the year ending March 15, 1899.

At the annual meeting a year ago the total membership of the Society was 461, of which 453 were members, 5 honorary members and 3 associates.

During the past year we have lost 17 members, 2 by death, 6 by resignation and 9 by forfeiture of membership for non-payment of dues.

There have been added to the Society during the year 40 members; 38 of these have been elected, 1 of whom was transferred from the Engineers' Club of St. Louis, and 2 former members have been reinstated. Our present membership consists of 5 honorary members, 5 associates and 474 members; a total of 484.

The record of deaths during the year is as follows:

James Francis, died December 1, 1898.

Charles E. C. Breck, died January 29, 1899.

Ten regular and two special meetings have been held during the year. The special meeting held on November 11 was devoted to exercises commemorative of the fiftieth anniversary of the organization of the Society. The seventeenth annual dinner of the Society was given at the Hotel Brunswick on February 7, 1899.

The average attendance at the meetings (not including the semi-centennial meeting and the annual dinner) was 75, the largest being 110 and the smallest 52. The attendance at the semi-centennial meeting was 170, and at the annual dinner 135.

The following papers have been read at the several meetings:

March 16, 1898.—Address by Past-President W. E. McClintock, "Road Construction." (Illustrated.)

March 30, 1898.—"Some Instances of Piles and Pile Driving, New and Old," by H. J. Howe.

April 20, 1898.—"State, City and Town Boundaries," by H. B. Wood. "Memoir of William C. Hall."

May 18, 1898.—"Co-ordinate Survey of Boston," by F. O. Whitney.

June 15, 1898.—"Modern Steam Plant for Electric Railways," by A. U. Jaastad. "Story of the Street Railway," by Gilbert Hodges.

September 21, 1898.—"Proposed East Boston Tunnel," by H. A. Carson. (Illustrated.)

October 19, 1898.—"Engineering Features of the Spanish War," by I. N. Hollis. (Illustrated.)

November 11, 1898.—Semi-Centennial Celebration. Opening Address, by President H. A. Carson. Historical Address, by Past-President Desmond FitzGerald, and Brief Address, by Samuel Nott.

November 16, 1898.—"The Maintenance of the System of Sewers in Newton, Mass.," by Stephen Childs.

December 21, 1898.—"Power and Equipment of Electric Railways," by Messrs. H. H. Hunt and C. K. Stearns. "Comparative Tests of Different Forms of Cement Briquettes," by Jerome Sondericker.

January 25, 1899.—"Experience in Sewer Construction," by L. M. Hastings. "Memoir of James Francis."

February 15, 1899.—"Grouting of Defective Work in the New Croton Aqueduct," by George S. Rice. (Illustrated.)

The informal meetings held in the Society's library have been continued during the year. The subjects discussed have been as follows:

March 23, 1898.—"Investigations as to the Restoration of Green Harbor, in the Town of Marshfield," by F. W. Hodgdon and X. H. Good-nough.

April 6, 1898, and April 27, 1898.—"A Few Thoughts on Dam Construction," by Reuben Shirreffs.

November 30, 1898.—"Providence Railroad Terminals," by G. B. Francis.

December 7, 1898.—"Longwood Avenue Bridge," by A. H. French.

January 11, 1899.—"An Account of Some of the Changes Made Along the South Shore by the Recent Storm," by F. W. Hodgdon.

February 1, 1899.—"Salt Water Fire System in Boston," by F. A. McInnes.

March 1, 1899.—"Plan and Engineering Work of the Associated Factory Mutual Insurance Companies," by L. H. Kunhardt.

March 8, 1899.—"Abolition of Grade Crossings at Readville, and at Other Points on the N. Y., N. H. and H. R. R.," by G. R. Hardy.

The attendance at these informal meetings has been fully as large as in former years, and in two or three instances as many were present as could be comfortably seated.

In accordance with the recommendation of this board, the Society at the April meeting appropriated \$50 for the purchase of standard engineering works. This appropriation has been expended and fifteen books have been added to the library. The board would recommend that the same amount of \$50 be appropriated for the purchase of engineering books during the coming year.

The report of the Treasurer shows that the Society has prospered financially during the year. Our permanent fund has increased \$829.90, and our current fund is \$702.46 larger than it was a year ago.

The lease to the Society of the Society rooms will soon expire, and the leases from the Society to the New England Water Works Association and the Hersey Manufacturing Company will expire before our next regular meeting. It is desirable that authority should be given to the Board of Government to act for the Society in relation to these matters, and that the President and Treasurer of the Society be definitely authorized to sign these leases.

The most important occurrence of the year has been the celebration of the semi-centennial of the founding of this Society. The first formal measures for its formation and the actual organization of the Society appear to have been effected during the spring and summer of 1848. It seemed desirable that the formal celebration of this semi-centennial anniversary should be held in the fall of the year in order to afford the most favorable opportunity for the attendance of the members. The celebration was held at the Hotel Vendome, on November 11, 1898, and the exercises were opened by the reading of letters of congratulation from various engineering societies, a retrospective address by President Carson upon Boston fifty years ago, after which Past-President FitzGerald delivered an address reviewing the history of the Society itself. A short address was made by Mr. Samuel Nott, one of the founders, and for many years Secretary, of the Society, and the remainder of the evening was devoted to social diversion, of which dancing formed an enjoyable part. The proceedings were of great interest throughout, and the occasion was exceptionally pleasant. Ladies were invited and many attended.

The relations between this Society and other engineering societies have been, as usual, pleasant. In particular it has always been true that this Society has always been a staunch supporter of the national society, the American Society of Civil Engineers. The present year is particularly auspicious for harmony of action since the American Society of Civil Engineers has elected for its President one of our Past-Presidents, whose good services to our own Society have been so conspicuous that no microscope is necessary to bring them to our vision, nor could any such instrument magnify the regard for him entertained by our Society.

Respectfully submitted for the Board of Government,

C. FRANK ALLEN, *Vice-President.*

ABSTRACT OF THE TREASURER'S AND SECRETARY'S REPORTS FOR THE YEAR 1898-99.

CURRENT FUND.

Receipts:

Dues from new members.....	\$208.00
Dues for year 1897-98.....	5.00
Dues for year 1898-99.....	3,176.00
Dues for year 1899-1900.....	18.00
Rent of rooms.....	800.00
Sale of JOURNALS.....	10.50
Interest on deposits.....	8.21
Fines on books.....	.91
Balance on hand March 17, 1898.....	224.53
	<hr/>
	\$4,451.15

Expenditures:

Rent	\$1,635.00	
Association of Engineering Societies.....	709.75	
Secretary's salary	400.00	
Printing and postage.....	344.83	
Periodicals and binding.....	92.70	
Incidentals	101.72	
Annual dinner	91.50	
Semi-centennial commemoration	10.75	
Books for the library.....	49.51	
Stereopticon at meetings.....	41.00	
Reporting meetings	8.00	
Lighting rooms	12.89	
Furniture	26.51	\$3,524.16
Balance on hand.....		\$926.99

Receipts:

PERMANENT FUND.

Thirty-seven entrance fees.....	\$370.00	
Shares of Merchants' Co-operative Bank, retired.....	263.00	
Subscription to Building Fund.....	50.00	
Interest and dividends.....	128.13	
Balance on hand March 17, 1898.....	1,075.49	\$1,886.62

Expenditures:

Dues on shares Merchants' Co-operative Bank.....	\$312.00	
Dues on shares Workingmen's Co-operative Bank.....	300.00	
Dues on shares Volunteer Co-operative Bank.....	300.00	
Deposit in Boston Five-cents Savings Bank.....	37.08	
Deposit in Provident Institution for Savings.....	37.53	986.61
Balance on hand.....		\$900.01

PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 15, 1899.

One Republican Valley Railroad bond (par value).....	\$600.00	
25 shares Merchants' Co-operative Bank.....	3,042.80	
25 shares Workingmen's Co-operative Bank.....	1,283.25	
25 shares Volunteer Co-operative Bank.....	1,237.50	
Deposited in Boston Five-cents Savings Bank.....	1,087.88	
Deposited in Provident Institution for Savings.....	1,101.47	
Deposited in Old Colony Trust Company.....	900.01	
	\$9,252.91	
Amount belonging to Permanent Fund March 16, 1898.....	8,423.01	
Increase during the year.....		\$829.90

TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

Permanent Fund	\$9,252.91	
Current Fund	926.99	
	\$10,179.90	
Total amount March 16, 1898.....	8,647.54	
Total increase during the year.....		\$1,532.36

REPORT OF COMMITTEE ON EXCURSIONS.

BOSTON, MASS., March 15, 1899.

Your Excursion Committee presents the following report:

Twelve excursions have been held during the year, as follows:

On April 20, 1898, to the South Union Station, at Boston, to see the erection of the roof trusses and other structural ironwork; attendance, 50.

On May 18, 1898, to Brookline, Mass., to inspect the Brookline Public Bath House and the stone arch bridges in the parkway; attendance, 20.

On June 15, 1898, to Everett, Mass., to visit the plant of the New England Gas and Coke Company, under construction; attendance, 29.

On July 22, 1898, an excursion down Boston Harbor, through the courtesy of Lieut. Col. S. M. Mansfield, Engineer Corps U. S. A., to witness the explosion of mines off Fort Independence and visit the Government shops at the fort; attendance, 230.

On August 19 and 20, 1898, to Portland, Maine, to visit, by invitation of the company, the works of the Portland Stoneware Company. The party was also given a trolley ride about Portland, a steamboat ride down Casco Bay and a shore dinner and theater party at Peaks Island; attendance, 29.

On September 21, 1898, to Middlesex Falls to see the New Stoneham Reservoir and Gate House at Spot Pond; attendance, 55.

On October 21 and 22, 1898, to Holyoke, Mass., where visits were made to the Riverside Paper Mills, the Deane Steam Pump Works and the new dam of the Holyoke Water Power Company, across the Connecticut River. A trip was also taken to the summit of Mt. Tom; attendance, 19, 13 of whom came from Boston, the remainder joining the party at Holyoke.

On November 16, 1898, to the plant of the Boston Electric Light Company; attendance, 30.

On December 15, 1898, to the South Union Station to inspect the head house and other buildings; attendance, 60.

On January 18, 1899, to the Boston and Oxford Exchanges of the New England Telephone and Telegraph Company; attendance, 40.

On March 1, 1899, to East Everett, Mass., to visit the works of the New England Structural Company; attendance, 18. (This excursion was arranged for the day of the February meeting, but was postponed two weeks on request of Mr. Douglass.)

On March 15, 1899, to the plant of the City Refuse Utilization Company, on Atlantic avenue, Boston; attendance, 20.

It will be seen that the total attendance on these excursions during the year has been 600.

The funds now in the hands of the committee amount to \$24.11.

Respectfully submitted,

R. S. HALE,

HENRY F. BRYANT,

LEONARD METCALF,

H. S. ADAMS,

BENJ. W. GUPPY,

Excursion Committee.

REPORT OF THE COMMITTEE ON THE LIBRARY.

BOSTON, MASS., March 15, 1899.

To the Boston Society of Civil Engineers:

GENTLEMEN:—The Committee on the Library presents the following report:

Since the last annual meeting there have been added to the library 489 titles. Of this number 312 are pamphlets and paper-covered reports and 177 are bound volumes. Fifteen volumes were purchased, 56 are periodicals and reports bound by the Society and the remainder were obtained by gift and exchange.

Of the shelf room vacant in 1897, about one-half has now been filled.

We have added a small revolving bookcase, in which it is proposed to keep the new accessions for a limited time before putting them in their proper places on the shelves.

One hundred and forty-six books have been borrowed from the library by members for home use, against 68 borrowed last year. Fines have been incurred for keeping books over time to the amount of \$0.54, which has been turned over to the Treasurer.

The work on the subject index of Municipal Reports progresses slowly. About one-half of the reports have been indexed and cards written. In order that the members may have the use of the index, although still incomplete, the cards have been put in the last drawer of the catalogue cabinet, and they will be added to as the work goes on.

Your committee recommends the appropriation of \$50 for the purchase of standard engineering books.

Respectfully submitted,

FRANK L. FALES, *Librarian*,
CALEB MILLS SAVILLE,
ANDREW D. FULLER,
FREDERIC H. FAY,
FRANK P. MCKIBBEN.

The Evolution of Engineering.

BY SIDNEY F. LEWIS, PRESIDENT.

[Read before the Louisiana Engineering Society, January 14, 1899.*]

IN complying to-night with the provision of our Constitution which requires of the President to make an annual address, I feel that I can hardly do justice to the honor, and I can scarcely hope that my efforts will prove either attractive or novel to my *confrères* around me.

The field of applied science has of late years become so broad, and the development of its numerous and varied applications so rapid, that in an address of this kind one feels at a loss how and where to begin in the treatment of the subject. We all recognize that with the progress of the age the profession is dividing itself into specialties, and, as the title of our Society indicates, our membership should find abundant opportunities to satisfy their professional ambition by mastering one of its various branches, instead of attempting to acquire proficiency in all. This of itself should be

*Manuscript received March 16, 1899.—Secretary, Ass'n of Eng. Socs.

an incentive to future encouragement in the growth and continued prosperity of our Society. The science of engineering does not owe its heritage to any stage in the world's history. While no one race or era can lay claim to its inception or its birth, every civilization may be said to have aided in its development.

If we trace the history of its beginnings, we find, from the records of early human achievements, that the early builders were guided by the knowledge of the results of experiences handed down from generation to generation, rather than by physical laws as established and considered in our enlightened age. From the beginning the progress of engineering development in every nation has been largely influenced by its political history.

Rulers of small states and principalities had little incentive to construct public works. But, as power became centralized and expansion of territory took place, wealth followed, and the perpetuity of civil power in the state was made dependent upon the extension of internal improvements and development of its resources. Wherever the centers of advanced civilization were located, there we find engineering works of importance.

With the ancient nations, every form of engineering was known which did not require the application of the generated forces. They built canals for transportation and irrigation, reservoirs and aqueducts, docks, harbors and lighthouses. They erected bridges of wood and stone, as well as suspension bridges, laid out roads, cut tunnels, constructed viaducts, planned roofs for their massive buildings, tested the strength of their materials, instituted elaborate systems of drainage, planned fortifications, designed engines of attack, built temples dedicated to their gods and the sun; in fact, covered, to a greater or less degree, all departments of hydraulic, bridge and road, sanitary, military and mechanical engineering, architecture and landscape gardening.

Among the many monuments of ancient engineering we read that the city of Nineveh, which stood on the east bank of the Tigris, was built of enormous dimensions, being fifteen miles in length, nine in breadth and forty-eight in circumference. The houses stood apart, each surrounded by gardens, parks and farms, whose size varied according to the rank and wealth of the respective proprietors. The city was inclosed within one wall as a common defense. This wall was two hundred feet in height, and so wide that three chariots might drive abreast, and upon it were constructed fifteen hundred lofty towers.

The city of Babylon stood in a plain and was perfectly square. The River Euphrates ran through the center of the town, and also supplied water to the ditches, which were excavated in front of the walls. The streets were perfectly straight, and crossed each other at right angles. The city was about fifteen miles in length, and consequently its perimeter was sixty miles. Its houses were built of bricks made of clay, found in its vicinity, sunburnt or burnt in kilns, and cemented with bitumen, with layers of rushes and palm leaves between the strata of brick. The walls of Babylon were three hundred feet high, and eighty-seven feet thick, and pierced by a hundred gates, all made of solid brass. Wide, straight streets, from each of the gates, crossed each other at right angles, which divided the city into six hundred and seventy-six squares, each of two and a quarter miles in perimeter. Some of these squares were used as parks or pleasure

grounds. A bridge passed over the Euphrates between two palaces on the opposite banks, which were also connected by means of a tunnel. The length of the bridge proper was an eighth of a mile, and its width thirty feet, and a long causeway or approach led to the bridge on each side of the river.

The temple of Belus, the supreme deity of the Babylonians, was the most wondrous structure of the city. It was, at its foundation, one-eighth of a mile in length, and about the same in breadth. Its height is said to have exceeded six hundred feet, which is greater than that of the Egyptian Pyramids. It was built in eight stories, gradually diminishing in size as they ascended. Instead of stairs, there was a sloping terrace on the outside, sufficiently wide for carriages to ascend. The temple was adorned with idols of gold. Palaces stood near the temple, and the inclosures and pleasure grounds of one of these palaces covered a space eight miles in circumference. Within its precincts were the celebrated hanging gardens, consisting of terraces one above another, raised upon pillars higher than the walls of the city, well floored with cement and lead, and covered with earth, in which the most beautiful trees and shrubs were planted.

The engineers of ancient Rome were especially noted for their ability to construct durable roads and aqueducts. The great system of military roads was begun by Appius Claudius (B. C. 312), who constructed a paved road to Capua, called from him the Appian way. Others followed after, all issuing from the capital. They bound the different cities and colonies not only together, but to Rome, and were the great highways by which intelligence was speedily carried and the Roman armies marched. In preparing to make a road, two trenches were first dug, parallel to each other, to mark the width. The width was about thirteen feet. The loose earth between these trenches was then removed, and the excavation was continued until a solid foundation was reached. In swampy lands a basis was formed artificially. Above the foundation, small stones were first laid, then a mass of broken stones about nine inches thick, cemented with lime, and above this were fragments of brick and pottery, about nine inches in depth, also cemented. Above this, large polygonal blocks of the hardest stone, fitted and joined with great nicety, were placed. The center of the road was a little elevated, to permit the water to run off. A footpath was constructed on each side. At about the same time (B. C. 313) Appius commenced the system of aqueducts which were to supply the capital with pure water from the Sabine Hills.

No undertakings of the Romans present more striking evidence of their energy, skill and untiring perseverance than the military roads and aqueducts. The latter were constructed at an expense of a vast amount of toil and money. Over hills, valleys and plains, and sometimes in subterranean channels, sometimes on long ranges of lofty arches. These subterranean channels were formed of stone or brick, and were arched in order to keep the water pure. Apertures were made for ventilation. The channel had a gradual slope, and the bottom was coated with cement. When the aqueduct was carried through solid rocks, the rock itself served as a channel. In order that the water should deposit the sedimentary matter which it held in suspension, large receptacles, or ponds, were made at convenient places for it to enter. In the city it was received into a reservoir, and thence conducted, through lead or earthen pipes, into smaller reservoirs in the

different districts which it was to supply. Four of the old Roman aqueducts are still in use. The New River in London, and the Croton aqueducts in New York, are constructed on the plan of the Roman aqueducts. It has been estimated that the total amount of water delivered by these aqueducts is equal to that of a stream twenty feet wide by six feet deep, constantly pouring into Rome at a fall six times as rapid as that of the River Thames, a volume equivalent to over 300,000,000 gallons per day.

They were the most wonderful structures of ancient Rome, and well might excite the admiration expressed by Pliny. "If any one will carefully calculate the quantity of the public supply of water for baths, reservoirs, houses, trenches, gardens and suburban villas, and along the distance which it traverses, the arches built, the mountains perforated, the valleys leveled, he will confess that there never was anything more wonderful in the whole world."

Their public and private baths, amphitheatres, temples and palaces exemplify the type of work constructed during the era of wealth and luxury, when Rome was mistress of the world. The power of the Roman Empire was upheld as much by the knowledge, genius and energy of its engineers as by its generals.

Rome, in her pristine grandeur, had her Coliseum and her Pantheon. Of the Coliseum Lord Byron, in "Childe Harold," apostrophises:

"While stands the Coliseum, Rome shall stand,
When falls the Coliseum, Rome shall fall,
And when Rome falls—the world."

The monuments of Roman engineering followed the paths of the conqueror; for, in every part of the world, from the shores of the Atlantic to the borders of India, from the Baltic to the Desert of Sahara, the engineer of that period has left the remains of his skill and ingenuity.

During the dark ages, from the downfall of the Roman Empire, about the fifth century, until the beginning of the sixteenth, the sciences were almost lost, being practiced only by the monks and other religious castes. Engineering development, since the beginning, has been influenced by the outgrowth of natural surroundings. In Greece, Italy, Switzerland and France the mountains, streams and gorges turned the attention of the engineer toward tunnels and bridges. So, in the lowlands of Holland and Belgium, the continual battles against floods developed a race of engineers with special skill in drainage and dyke building, while in England, surrounded on all sides by a stormy sea, thought was directed to light-houses, harbors and docks.

In the early part of the sixteenth century, our Dutch ancestors began their work of adding to the area of their country by building canals and dykes and reclaiming land. And, as Holland gradually provided herself with her magnificent system of artificial waterways, her industrial energy was rewarded as the people increased in prosperity, and attained a position of power among the nations of Europe, developing among her people traits of character which were inherited by those who were afterwards to found the metropolis of the New Republic. In Italy the reclamation of its marshes and submerged lands took place in the seventeenth century. In Russia, Peter the Great devoted his time and energy to internal improvements, and laid the plans for a system of inland navigation to connect the new city of St. Petersburg with the Caspian Sea.

Under the reign of Louis XIV of France (1638-1715) systematic improvement of the public highways leading to Paris was inaugurated. The Languedoc Canal was built, and the city of Paris was paved and lighted, during his reign. The Academy of Inscriptions in 1663, the Academy of Sciences in 1666, and that of Architecture in 1671, were founded, and the "Commissary General of Fortifications" was created by him. "L'École des ponts et Chaussées" was established in 1720, and in its walls have graduated many able and practical engineers. In 1803, Napoleon Bonaparte, during his Consulship, founded the University of France, and, three years later, in 1806, he removed the Military School from Fontainebleau to St. Cyr, and it has furnished France and the world with many distinguished military and civil engineers. Although England produced eminent engineers in the sixteenth and seventeenth centuries, she was dependent, for her engineering, even more than for her pictures and music, upon foreigners. Technical knowledge lay dormant with her people until the steam engine was introduced. At the time when Holland had made great progress in internal improvement, and in her systems of water communication, and when France, Germany, and even Russia had opened up important lines of inland navigation, there was not a single canal in all England, and her common roads were about the worst in Europe. The Flemings introduced cloth making and linen weaving, and the first windmills and water-mills, while the Dutch introduced the manufactory of pottery, and the first engine for pumping purposes. The first cannon cast in Sussex county was cast by a Frenchman, and the great level of the Fens was drained by Vermuyden, a native of Zealand. A German established the first paper mill at Dartforth, and the first mines were worked by Germans under the reign of Queen Elizabeth.

In the latter part of the eighteenth century attention was directed to the betterment of her highways and internal improvements, and, from this period on, her native engineers have constructed a magnificent system of canals, turnpike roads, bridges and railways. They have built lighthouses (finger posts of the sea) around the coast.

They have hewn out and built docks and harbors for the accommodation of a gigantic commerce, whilst their inventive genius has rendered iron, fire and water the most untiring workers in all branches of industry, and the most effective agents in locomotion by land and sea.

The progress of engineering science in America from 1775 to 1825 was largely directed by Frenchmen who came to this country at the solicitation of our Government. The geological features of America, comprehending its sheltered harbors, mighty rivers and lakes, lofty and wooded mountains and boundless prairies, have offered special difficulties which have been overcome by the skill of her engineers, and their monuments are typical of our advanced civilization, our bridges, our high and colossal buildings, our vast system of railways, the improvement of our waterways and harbors, the reclamation of our lands from overflow, our electric railways and electric lighting, and other municipal and industrial works. In these things are embodied the most distinguished achievements of the American spirit, the development of which has been achieved in the last fifty years, and, if the progress of engineering science in the future continues, as in the last half century, increasing and extending the benefits resulting from the works of our engineers, they will justly be regarded as ranking among the greatest benefactors of their country.

Engineers' Club of St. Louis.

488TH MEETING, APRIL 5, 1899.—The meeting was called to order at 8.15 P.M. by President Colby. Thirty-one members and ten visitors were present. The minutes of the 487th meeting were read and approved. The minutes of the 272d meeting of the Executive Committee were read. The name of Mr. Hiram Phillips having been recommended by the Executive Committee, he was balloted for and declared elected a member of the Club. Mr. W. A. Layman then read the paper of the evening, entitled "Alternating Current Power Motors." The various uses to which motors may be put were mentioned. Ten years ago alternating current motors were regarded as mere laboratory playthings, whereas to-day they are of commercial importance. The use of the great Niagara Falls power plant for supplying current for power purposes is an illustration of the growth of the use of this type of motors.

The difference between the direct and alternating currents, and the methods of generating currents of several phases, were described and illustrated by means of diagrams. The development of the induction motor by Tesla and the results of his investigations were pointed out. While there have been many types of two and three-phase motors brought out, there has not been, until lately, a successful single-phase motor. A motor of this type is highly desirable because of its applicability to the common lighting circuit, and because it necessitates no change in the power house equipment. The essential differences between the single and multiphase motors, and the details of a successful single-phase motor as built in St. Louis, were fully described. Some interesting results of tests on a 5 horse power motor were illustrated graphically by diagrams. The discussion following was participated in by Messrs. Flad, Bryan, Humphrey, Colby, Nipher, Pillsbury and Borden. After a few remarks by the President concerning the next meeting, and the announcement of the paper for that evening, "The Engineers' Club of St. Louis, Its History and Work," by Mr. W. H. Bryan, the meeting adjourned.

E. R. FISH, *Secretary*.

489TH MEETING, APRIL 19, 1899.—The members of the Club assembled at the Southern Hotel at 7.30, and at about 8 P.M. entered the main dining room, where a course dinner was served. After dinner the meeting was held in the grand parlor, being called to order at 9.30 P.M. by President Colby. Forty-four members and forty visitors were present. As the meeting had been arranged in celebration of the 30th anniversary of the Club's incorporation, the usual routine business was omitted. The program was as follows:

Piano solo	Miss Cora E. Fish
Remarks by the President.....	Mr. B. H. Colby
Vocal solo	Mrs. Alice Waite Perkins
The Engineers' Club of St. Louis, Its History and Work..	Mr. W. H. Bryan
Vocal solo	Mr. W. H. Jones
Remarks by Members.	
Vocal solo	Mr. W. H. Jones
War Scenes.	
Vocal solo	Mr. J. A. Laird

Mr. Bryan's paper was the main feature of the evening. It gave the history of the Club from its inception, and also notes on each of the Past-Presidents, charter members and other prominent persons who have been connected with the Club, telling something of each one's work. Portraits were shown of all by means of a stereopticon, and in many cases some of the principal works with which they had been identified. The paper was very complete and is a valuable addition to the records of the Club.

The remarks by members consisted of short reminiscences, Mr. Wm. Wise, Mr. R. E. McMath, Prof. C. M. Woodward, Mr. M. L. Holman and Col. E. D. Meier being called upon and responding. A congratulatory telegram from Mr. Wm. Eimbeck, one of the charter members, was read. Owing to the lateness of the hour the war scenes were omitted. After a humorous song by Mr. Laird, the meeting adjourned at 11.30 P.M., having been entirely successful and most thoroughly enjoyed by all present.

E. R. FISH, *Secretary*.

Detroit Engineering Society.

THE 38th regular meeting of the Society was held in the smaller lecture room of the Detroit Art Museum, Friday, March 24, 1899; President Geo. Y. Wisner presided. There were about one hundred and ten members and guests, including many ladies, present. The paper of the evening, "Locks and Lock Gates for Ship Canals," was read by the author, Mr. Henry Goldmark. It was illustrated by eighteen lantern slides, made mainly from photographs of the locks at Sault Ste. Marie, Mich.

Adjourned.

HENRY GOLDMARK, *Secretary*.

A SPECIAL meeting of the Society was held at the Hotel Ste. Claire Friday, April 7, 1899; First Vice-President W. J. Keep presided. Mr. W. C. King was elected to resident membership. The evening was devoted to a discussion on "Locks and Lock Gates for Ship Canals." It was opened by Mr. Henry Goldmark and participated in by Messrs. Woodard, Dunlap, Himes, Pope, E. Molitor, D. Molitor and Russel.

Adjourned.

HENRY GOLDMARK, *Secretary*.

THE thirty-ninth regular meeting (fifth annual meeting) of the Society was held at the Hotel Ste. Claire, Friday, April 21, 1899. President G. Y. Wisner presided, and there were forty-two members and guests present.

The annual election of officers was held, and resulted in the choice of the following officers for 1899-1900:

President—W. J. Keep.

First Vice-President—Alex. Dow.

Second Vice-President—Willard Pope.

Secretary—Henry Goldmark.

Treasurer—P. H. Hinchman, Jr.

At the close of the business meeting the members and guests adjourned to the dining room and partook of the annual banquet.

The tables were arranged as in preceding year in the form of an open square.

Informal addresses were made by the retiring President, Mr. G. Y. Wisner, by Profs. C. E. Greene and M. E. Cooley, of the University of

Michigan; by Mr. C. S. Harrison, of Chicago; Mr. E. E. Haskell, Mr. David A. Molitor, Mr. Alex. Dow, Mr. H. Goldmark, the President-elect, Mr. W. J. Keep and by Mr. G. S. Williams, the late Secretary, who was warmly welcomed to the meeting.

Adjournment did not take place till the small hours.

HENRY GOLDMARK, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR MEETING, APRIL 7, 1899.—Called to order at 8.30 P.M. by President Percy. The minutes of the last regular meeting were read and approved. The following were elected to membership, by ballot: Members—Geo. N. Randle, assistant engineer, Board of Public Works, Sacramento; W. C. Elsemore, city engineer, Eureka; H. A. Brigham, mining engineer, San Francisco; Walter de Buxton, assistant engineer Santa Fe Railroad, Arizona. Associates—F. E. Knowles, San Francisco; J. W. Miller, San Francisco.

Mr. Marsden Manson read a paper, entitled "Notes on the Relation Between the Geology of Catchment Areas and Disease," which was discussed.

The President welcomed to the Society Mr. F. C. Prindle, civil engineer, U. S. Navy, who visited the rooms, and discussed Mr. Manson's paper, relating certain conditions of wells now boring at Goat Island for the Naval Training Station.

Adjourned.

OTTO VON GELDERN, *Secretary*.

Civil Engineers' Club of Cleveland.

THE regular meeting was held at Case School of Applied Science on April 11, 1899.

The laboratories were open at 7 o'clock and were visited by many members and friends. The new 100-ton testing machine and the steam turbine received special attention.

The meeting was called to order at 8.15 P.M. in the Electricity Building by Vice-President John W. Langley. Present, thirty-three members and fifteen visitors.

Mr. N. P. Bowler moved that the reading of the minutes be omitted; seconded by Mr. J. N. Coffin, and carried.

Messrs. H. M. Lucas and C. O. Palmer were appointed to canvass the ballots for the election to active membership of Ernest Starr Jackson and Howard P. Fairfield.

A letter from Mr. Ambrose Swasey was read containing the announcement that he had presented the Club with a new projection lantern. Dr. Chas. S. Howe moved a vote of thanks to Mr. Swasey. Many seconds were offered. Carried.

A letter from Mrs. Kimball was read, in which she thanked the Club for the expression of sympathy given at the time of the death of Mr. Hiram Kimball.

Dr. Chas. S. Howe, of the House Committee, reported that rooms had been rented in the Arcade for the joint use of the Technical Clubs, that they were now being decorated and furnished and would be ready for occupancy about May 1.

Mr. F. S. Barnum, of the Banquet Committee, reported progress, but that the arrangements were not yet completed.

Prof. Chas. H. Benjamin then read the paper of the evening, entitled "The Power Consumed by Shafting and Belts." It was illustrated by slides.

The experiments described in the paper were made on the shafting and belts used to drive the machine shop at the school, by the aid of a Flather recording dynamometer.

The dynamometer itself was shown, being driven by a motor in such a manner as to show its operation.

Copies of the diagrams drawn by this machine were shown on the screen, as well as tables giving the powers consumed by the different machines and the shafting in the shop.

In these experiments the horse power required to drive the shaft alone was found to be about one-third that required for shaft, belts and loose pulleys. The effect of flooding the shaft bearings with oil was clearly shown on the diagram.

When the shop was run under ordinary conditions the friction of the shafting and belts was found to consume more than half of the total power.

When the machines were worked to their full capacity the power was distributed about as follows:

Cutting metal.....	43 per cent.
Empty machines	32 "
Shafting and belts.....	25 "

Dynamometer cards as diagrams, from some of the machines such as lathes, planers and shapers, were then shown on the screen and explained.

After the paper was read it was discussed by Messrs. Palmer, Benjamin, Cowles, Langley and Reed.

The tellers' report was then read and the election of Ernest Starr Jackson and Howard P. Fairfield to active membership announced.

After adjournment at 9.30 lunch was served in the Mechanical Laboratory.

THE semi-monthly meeting was held at the Central Manual Training School, April 25, 1899.

After an inspection of the building and equipment the meeting was called to order by President Jared A. Smith, at 8.20 P.M. Present, twenty-two members and seven visitors.

A few appropriate words were spoken by President Smith about the death of Mr. Stiles H. Curtiss, member of the Club.

The paper of the evening was then read by Mr. Lewis C. McLouth. The subject was "Manual Training," and the following is an extract:

In the early times, when the country was new and the land uncultivated, it was necessary for the people to struggle hard for their living. No one could live without hard labor, and it was this labor which brought about marked advance in civilization.

The women spent the long winter evenings in knitting, spinning and weaving, while the men and boys fashioned, with crude tools, articles of use and some beauty.

Industrial handwork was an essential part of the life of the people, and that their general happiness and moral welfare depended upon it was keenly felt.

As time passed on, the home industries had to give way more and

more to other interests, and machines were introduced, depriving the hands of occupation.

After a time it began to be felt that the general health, happiness and morals of the people were not so strong as in the olden times, and educators began to reflect upon ways and means to renew the old home industries and the conclusion was reached that schools should be established for teaching manual training.

From this it will be seen that manual training is not an outgrowth of trades or trade schools, nor of commercial handicraft, neither is it a system of training based on tools, material and construction, but is a system which has grown out of and is based upon the material needs of humanity. This seems to me to be the only rational reason for putting manual training into the schools.

Shopwork is the characteristic element in the manual training school, but adding shopwork to the regular curriculum does not make a manual training high school. In some cases it has been merely tacked on, and is the shopwork of the mechanic and not of the teacher. On the contrary, manual training may and should be in living touch with all parts of the course, and in many cases might be the very backbone of it.

It is accepted as essential to the best development of the child.

Educators realize that to work with the hands makes a boy a better boy, and to-day we have a school that is more than the trade school. We cannot teach all of carpentry or forging, but must select that which is of most value to the pupil.

The demands made upon each individual, in order to fill his position in life creditably and with a fair prospect of success, are greater now than ever before. It is not likely that this general activity and progressiveness in the commercial and industrial world will cease, consequently the necessity for an education that is many-sided, that will equip the individual with intelligence, skill and power to grapple with the difficult problems of life.

Professor John D. Runkle, once President of the Boston School of Technology, said: "Public education should touch practical life in a greater number of points; it should better fit all for that sphere in life in which they are destined to find their highest happiness and well-being. It is not meant by this that our education should be lowered mentally."

While manual training schools do not aim to teach the boy or girl a trade or profession, they do train the capable hand through practice and instruction, and cultivate a practical intelligence in the individual that enables him to make a fair start in life.

If we protect the children of the very poor from the worst consequences of their condition without making paupers of them or their parents, we must continue (after the training of the kindergarten) in some way to give them study and work together.

Chas. H. Ham, of Chicago, says: "Mechanics stand the test of scrutiny better than merchants; civil engineers and architects are more competent than railway managers, lawyers, judges and legislators; ninety-seven per cent. of the merchants fail; lawyers and judges produce a most pitiable wreck of justice, and the statutes of legislators wear out in a year; but every locomotive that leaves the shop is perfect, bridges last a century and the works of architects and builders stand as monuments of skill and fidelity long after their makers are turned to dust."

Then why store the mind with facts that are useless until applied to things, and unless they are applied to things? If they are to be applied to things, why not teach the art of so applying them? An education without this is, one-sided, incomplete, unscientific.

The paper was followed by a discussion by Messrs. Smith, McLouth, Howe, Langley, Reed, Benjamin, Kendall and Herman.

All supported very strongly the idea of manual training in the public schools, not only for its physical benefits, but also for its moral training and its tendency to make honest labor with the hands appear more honorable and dignified to the youth.

It was moved by Mr. Wm. Reed, and seconded by Dr. Chas. S. Howe, that a committee of three be appointed by the chair to draft resolutions upon the death of Mr. Stiles H. Curtiss.

Mr. Ambrose Swasey, Dr. Cady Staley and Mr. Edward H. Harvey were appointed.

Meeting adjourned at 9.45 P.M.

ARTHUR A. SKEELS, *Secretary*.

Montana Society of Engineers.

A REGULAR meeting of the Society was held in Helena on April 8, 1899; Mr. James S. Keerl in the chair. The minutes of the preceding meeting in the city of Butte were read and approved. Applications for membership were presented and acted upon. Messrs. Finlay McRae and W. S. Fortiner were appointed tellers to canvass the votes for membership, which showed that Clarence V. Page, of Butte, and Lewis C. Parker, of Garnet, were elected members. The proposed amendment to Article V of the By-Laws, presented at the meeting in Butte, was discussed and the Secretary directed to have same printed and sent out to be voted upon by letter ballot. The proposed change of the headquarters of the Society to Butte was discussed, all agreeing that it was advisable to make this change as soon as possible, and that the change would be for the best interests of the Society. It was advised that the President appoint a committee to draft an amendment to the Constitution and By-Laws to provide for this change, and that said committee report at the May meeting, to be held in Butte.

No further business appearing, the meeting adjourned.

A. S. HOVEY, *Secretary*.

Engineers' Club of Cincinnati.

105TH REGULAR MEETING, CINCINNATI, O., APRIL 20, 1899.—Dinner was served at 6.15 P.M. Regular meeting was called to order at 7.15 P.M.; with President Hazard in the chair, and seventeen members present.

Minutes of the meeting of March 16 were read and approved.

Applications for associate membership were received from C. H. Davidson, of the Cincinnati Granitoid Co., and Wm. E. Green, representative of the Warren & Webster Co. and the Jewell Filter Co.

The following new members were elected: Messrs. L. S. Rose, Chas. L. Parmelee, Wm. E. Gunn, Chas. A. Knowlton and John A. Hiller.

The committee to prepare a memoir to Fred. C. Weir reported that the same would be ready for presentation at the next meeting.

Mr. Elzner, as editor of the "Question Box," read communications from two of our absent members, Messrs. Chas. A. Ewing and Hugo Diemer, which contained matter of interest.

The paper for the evening was read by Mr. A. O. Elzner on the subject, "The Development of Church Architecture," which was illustrated by numerous cuts, plates and photographs, and was quite thoroughly but informally discussed.

Adjourned.

J. F. WILSON, *Secretary*.

ASSOCIATION OF ENGINEERING SOCIETIES.

VOL. XXII.

MAY, 1899.

No. 5.

PROCEEDINGS.

Civil Engineers' Club of Cleveland.

A Review of its Past, with Some Suggestions Regarding its Future.

ANNUAL ADDRESS BY FRANK C. OSBORN, RETIRING PRESIDENT, MARCH 14, 1899.

ON the evening of February 28, 1880, eleven engineers, Messrs. S. J. Baker, C. H. Burgess, John B. Davis, G. Geuder, G. Lindenthal, A. Mordecai, J. S. Oviatt, Hosea Paul, Walter P. Rice, J. Wainwright and C. N. Walter, met at the office of the County Surveyor for the purpose of organizing for mutual improvement and for social intercourse a club or society to be known as a civil engineers' club, or engineering society, as the corporate members might decide, the organization to include such of the civil engineers of Cleveland and vicinity as might choose to connect themselves therewith.

A very decided difference of opinion appearing among those present, the following resolution was offered by Mr. Paul, and adopted by the meeting with the understanding that the action of the meeting should in no way control a full discussion of the resolution at a future meeting:

"Resolved, That the active membership of this Society be restricted to civil engineers."

On March 9, 1880, the Constitution was adopted with the exception of but one clause, that governing the name of the organization, the committee having been given until the next meeting to report.

On March 13, 1880, Mr. Mordecai, chairman of the committee, reported in favor of adopting the name "The Engineers' Club of Cleveland." Mr. Rice presented a minority report favoring the name "The Civil Engineers' Club of Cleveland." The minority report was adopted. At this meeting the first officers of the Club were elected.

The following is a list of the charter members: Samuel J. Baker, Clarence M. Barber, C. H. Burgess, H. M. Clafin, John D. Crehore, Robert Cudell, John B. Davis, Otto Dercum, G. Geuder, A. S. Hovey, G. A. Hyde, Chas. Latimer, G. Lindenthal, A. Mordecai, Jas. S. Oviatt, Chas. Paine, Hosea Paul, M. E. Rawson, Wm. Reuchel, Walter P. Rice, Simeon Sheldon, Chas. H. Strong, E. O. Schwagerl, John Wainwright,

Chas. A. Walter, A. M. Wellington; a total of twenty-six names. Nine of these, Messrs. Baker, Barber, Claflin, Dercum, Mordecai, Paul, Rawson, Rice and Strong, are still active members. Mr. Lindenthal is now a corresponding member, Mr. Paine an honorary member; Messrs. Crehore, Cudell, Latimer, Oviatt, Sheldon and Walter died while members of the Club; Mr. Wellington was not a member of the Club at the time of his death. Of the remaining eight charter members, five, Messrs. Geuder, Reuschel, Burgess, Davis and G. A. Hyde, are still residents of the city and in active service. Messrs. Hovey, Schwagerl and Wainwright have removed from the city and are no longer connected with the Club.

On the 27th of March, 1880, a special meeting was held in the Board of Education rooms. President Charles Paine delivered an inaugural address to an audience of about one hundred persons, many of whom were ladies.

April 3, 1880, was a banner meeting for admission of members, forty-five being elected by acclamation. At this meeting a committee was directed to open up a correspondence with other similar societies in regard to a common publication.

On June 5, 1880, a Committee on Quarters reported in favor of a room in Case Library.

The Society lost its first member by death January 4 1881, in the person of Gen. Chas. B. Stewart.

On January 8, 1881, resolutions were passed leading to the publication of a joint pamphlet with the Boston, Chicago and St. Louis Societies. At this meeting also the dues were raised from \$4.00 to \$6.00, the increased figure to include Case Library membership fee.

On April 2, 1881, the Club met for the first time in its room in the rear of the newspaper room at Case Library. At this meeting the regular meeting night was changed from the first Saturday to the second Tuesday of each month.

At the meeting of May 29, 1881, President Chas. Paine proposed the establishment of a public bench mark of known elevation above sea level, and a committee was appointed to look into the matter.

On September 14, 1881, Mr. Paine resigned his membership on account of removal from the city. He was succeeded as President by Col. John M. Wilson. Mr. Paine took a great interest in the Club, donating many books and giving his time very freely to further its best interests.

March 11, 1882, appears to be the first record of our customary annual banquet. The Club dined at the rooms of the Windsor Club, listened to the annual address, other papers and remarks.

In June, 1882, the Engineers' Society of Western Pennsylvania, headquarters at Pittsburg, visited Cleveland, and was entertained by this Club.

On October 13, 1882, a reception was tendered Col. John M. Wilson, the occasion being his departure to Washington on account of his promotion.

He now holds the rank of Brigadier-General and the position of Chief of Engineers in the United States Army. He is still an honorary member of the Club and greatly interested in its welfare. He donated many books and maps, and long ago listed the name of the Club for all publications of the United States Engineers' Department.

On June 12, 1883, this Club joined with the American Society of Mechanical Engineers in the opening session of their annual convention in this city.

On February 12, 1884, by resolution offered by Mr. Rice, a committee was appointed to investigate the subject of pavements in various cities.

On April 20, 1884, the Club was favored with a poem by Mr. John H. Sargeant, the title being "The Three Seventies, 1814, 1884, 1954."

On June 25, 1884, the American Institute of Mining Engineers held a convention here, and this Club extended proper courtesies.

On July 8, 1884, information reached this Society that the Western Society of Engineers contemplated withdrawing from the Association of Engineering Societies. The Club immediately took the matter up, asking the Western Society to reconsider taking such action. This action of the Club probably had some weight with the Chicago Society, as they did not at that time withdraw from the Association. They did, however, withdraw during the year 1895.

On April 14, 1885, a resolution was adopted to procure cabinet photographs of members removed by death or otherwise, with a suitable case or frame for same. At this meeting action was taken regarding the placing of civil engineers on an equal footing with military engineers in public works other than military.

On August 11, 1885, Lord Sackville Cecil, Manager London District Underground Railroad, gave the Club a talk on the subject of the operation of that road.

On December 3, 4 and 5, 1885, a convention was held here of delegates from various societies in consideration of the relation of civil and military engineers on public works. Twenty-five societies were represented, and this Club took the initiative and a prominent part in the deliberation.

In the spring of 1886 a paper was read by Mr. Ritchie on "The Garfield Monument." Quite an interesting discussion resulted on the subject of the engineering problems involved. A committee was appointed to investigate the subject, which committee was very well treated by Mr. Wade and others.

On January 11, 1887, a committee was appointed on Standard Time, and rendered a report on January 25, at which time a committee was appointed to confer with the City Council.

On March 22, 1887, Mr. Sargeant read a paper on "Street Pavements, Past, Present and Future." A number of letters from various cities on the subject of pavements proved interesting and valuable.

At the next meeting April 12, 1887, an interesting discussion took place on the subject of pavements.

On February 14, 1888, resolutions were adopted regarding the appointment of civil engineers on public works.

On October 8, 1889, the question of affiliation with the American Society of Civil Engineers was taken up, discussed and referred to a committee.

March 11, 1890, was the date of the tenth annual meeting. The President called particular attention to the excellent condition of the Club, and the Secretary's report showed that there had been no resignations and no deaths for that year.

On March 27, 1890, the tenth annual banquet was held at the Kennard House, about two hundred members and guests being present.

On April 8, 1890, President Searles spoke of the need for more commodious quarters. A committee to investigate the question of larger quarters was appointed, and continued to serve for about two years, but no

definite action was taken. At this meeting Mr. Eisemann reported that the Chapter of Architects wished to affiliate with this Club for joint use of rooms and other purposes. At this meeting a communication was read from the American Society of Civil Engineers asking for the appointment of a committee for a conference regarding affiliation.

On July 8, 1890, a report was received from Mr. Holloway, who represented the Club at the conference in New York on the subject of affiliation with the American Society of Civil Engineers, to the effect that the attendance was small and nothing was accomplished.

On September 9, 1890, the third Tuesday in October was set aside for the purpose of visiting certain manufacturing plants in a body. The Club on that day visited the Cleveland City Forge Works, the Brown Hoisting and Conveying Machine Company and the Otis Steel Company.

On March 10, 1891, a new Constitution, substantially as compiled by Mr. Searles, was adopted by ballot. It was reported at this meeting that the Club owned one hundred and forty-two bound volumes in the library and two hundred pamphlets.

On May 12, 1891, the Executive Board was instructed to have the Club incorporated. This was done as soon as practicable, the date of incorporation being May 29, 1891. At this meeting there was some discussion about changing the name of the Club before incorporation, but no action was taken.

September 29, 1891, was a visiting day. The Club visited the City Water Works Pumping Station, Globe Iron Works, Shipowners' Dry Dock and Walker Mfg. Co.

November 4, 1891, was another visiting day. The Club visited the Cleveland Rolling Mills, after having taken supper at the Forest City House. The Club also visited the power house of what was then the Broadway and Newburgh Street Railway Company.

March 8, 1892, was the twelfth annual meeting. The Secretary reported that the largest attendance during the year was sixty, average thirty-five, and smallest attendance twenty. The Treasurer's report was not so favorable, as it indicated a deficit of \$46.70.

At the meeting of July 12, 1892, Prof. Howe discussed statistics of the census reports from 1820 to 1880, deducing therefrom a formula for the future population of Cleveland. Prof. Howe's formula gives for the population of Cleveland in 1900, 396,587. A fair estimate for the population of Cleveland at this time would be 375,000.

At the annual meeting on March 14, 1893, there was quite an interesting discussion as to whether wine should be served at the annual banquet or not. The question was finally referred to letter ballot, the result of which was to the effect that wine be not served. Considerable feeling was aroused by the result of the discussion, and the result was that no banquet was held. At this time steps were being taken toward the remodeling of the Case Building, and there was talk of more commodious quarters for the Club in connection with the new building.

On March 13, 1894, the annual meeting was held at the Chamber of Commerce rooms, the Case Library Building being remodeled at this time. The Secretary's report showed a membership of one hundred and eighty-eight and an average attendance for the year of forty.

Early in May, this year, the Club visited the power house of the Big Consolidated Electric Railway.

On February 12, 1895, the Club met again in Case Library for the first time for a year. On February 12, 1895, the dues were increased to \$10.00 by amendment to the Constitution.

At the annual meeting, March 12, 1895, the Secretary's report showed a total membership of one hundred and eighty-one, a loss of seven from the previous year.

On February 25, 1896, the Club took favorable action concerning the adoption of the metric system. This action was taken in response to a request from the House of Representatives.

At the annual meeting in March, 1896, the Secretary's report showed a total membership of one hundred and sixty-four; four new members were elected, fourteen members dropped from the rolls for non-payment of dues and six resignations were received. Notwithstanding the drop in membership, the average attendance was forty-eight.

During the winter of 1896-97 considerable work was done by a committee toward the formation of a proposed academy of science. The committee reported on February 9, 1897, to the effect that it was not to the interest of the Club to pursue the question further at that time.

The annual meeting, March, 1897, showed a membership of one hundred and ninety-one and an average attendance of fifty-five and one-half.

At a special meeting, April 6, 1897, a very able report was presented by the Committee on New Quarters, which consisted of Messrs. Searles, Miller, Swasey, Gobeille and Howe. This committee reviewed the career of the Club at some length, and argued strongly in favor of the plan for the purchase of a house. The plan suggested, however, was not carried out. The idea, though, was not entirely given up, and on February 22, 1898, at the semi-monthly meeting, the special order of business was the report of the Committee on New Quarters. After very long and thorough discussion, the committee was continued.

At the annual meeting, March 8, 1898, the Secretary's report showed a membership of one hundred and ninety and an average attendance for the year of thirty-five members and six visitors. The house question was still under discussion.

On April 13, 1898, the Club visited the new plant of the Cleveland Shipbuilding Company, the occasion being the launching of the steamer "Superior City."

Regular meetings were held right through the summer, and considerable discussion was carried on regarding a change of name. The discussion finally resulted in leaving the name of the Club as it always has been.

On December 13, 1898, the question of new quarters in the Chamber of Commerce Building was taken up, and before a lease was entered into the matter took a different shape, rooms in the Arcade coming into the argument, so that it is still uncertain where the Club will be quartered in the future.

Probably the most important matter before the Club at the present time is the question of uniting with three other Cleveland societies—viz, the Electric Club, the Chemical Society and the Architectural Club—in the occupation of common quarters. The prospect for the consummation of this project is at present very encouraging, and it is hoped and believed that it will result in great good to the several societies, as such, as well as to the individual members thereof. The publishing of a joint bulletin will

advise each member of each society of the coming meetings and subjects for discussion of all four societies. This will naturally increase the attendance at all meetings, as almost any topic pertinent to one society should prove of interest to many of the members of the others. An increase of membership in all societies would naturally follow, also, as each society can offer advantages incident to the union not now possessed by the individual societies.

The coming in contact of the members of different societies is sure to be of benefit to all on account of the broadening influence which will necessarily result. In having rooms that we may feel are our own, and which will be open at all times, it is believed that a more social feeling will develop and that many of the members will be found at the rooms during leisure hours of afternoon and evening. It will be practicable also to provide for frequent informal meetings of a social character, instead of limiting ourselves to only one such occasion each year, as represented by our customary annual picnic.

The closer union of several societies will give us additional political strength, using the term in its best sense, and put us in much better shape to propose and carry through such legislation as, after full consideration and investigation, we may in our combined wisdom deem advisable. The medical and legal professions have the benefit of laws enacted in their general interests. Is it not feasible to have similar laws enacted in the interest of the engineer? Proper legislation would benefit not only the engineer, but would be of advantage also to the client, whether individual, corporation or municipality. A quack engineer is, if anything, a more dangerous thing than a quack doctor. The latter has in general but a single life at stake, while the engineer is responsible for the safety of thousands of human beings who are compelled to traverse his structures. The health of entire communities depends largely on the proper source of water supply and on a properly designed and constructed system of sewerage.

Immense sums of money are continually being spent in carrying out the designs of engineers, and much of it spent under their direct supervision. How important it is, then, that the engineer be qualified by previous training and experience to design skillfully and to execute promptly, economically and honestly. Is not the chief engineer of a great railway system as important an official as the general counsel? And has he not as great responsibilities? Is not the chief engineer of a municipality, whose duty requires him to design and superintend the construction of sewers, streets, water works, bridges and other works, amounting to thousands of dollars in cost, as important an official as the health officer? The answer to these questions must surely be an affirmative one, and leads naturally to the suggestion that this Club should at an early date take up the question of legislation, ascertain what has already been done in this and other States for this and other professions and formulate some plan of securing to Ohio engineers at least the legal standing and protection to which by right they are entitled.

The question of compensation for the engineer in independent practice is an important one. The architects have a schedule of prices for different classes of work which is apparently satisfactory and which is generally adhered to by the better class of architects. It would be idle to say all architects adhere to the schedule. All engineers would not adhere to a schedule if they had one. The schedule would be a standard, however, and

would probably be adhered to by the better class of engineers. It would tend to educate the public to a proper valuation of the engineer's services. It would increase the respect of engineers for their own work. If anything is ever done in this direction, somebody must start the movement. The suggestion is ventured that the Civil Engineers' Club of Cleveland take the initiative.

This Club, to make the most of its opportunities, should enlist in its ranks as many as possible of the local engineers and others who are qualified for membership. The list of associate members in particular could be largely increased by a properly organized effort. A Committee on Membership could do a great deal of good by looking up the names of men who would be desirable as members and bringing the Club to their attention. This committee could be of value also in seeing that newly-elected members are introduced to the officers and other members of the Club.

The resolution of April 14, 1885, providing for the obtaining of photographs of members removed by death or otherwise was a good one, and should be put into effect. It might be improved upon by obtaining as well the photographs of the most prominent members of the Society who are still with us.

The visiting days formerly in vogue were of much interest and value, both from a professional and from a social standpoint, and as there are still a number of places that could be profitably visited, it is to be hoped that these excursions will be revived.

The records show that the Club has from the start been progressive and public spirited, taking a proper interest in local questions as they came up. This spirit should, of course, be cultivated and the Club should do its utmost to make its importance felt and appreciated in this vicinity. A local society such as ours has before it a field of usefulness not enjoyed by the national societies, and a part of our duty should be to educate the public to a proper realization of the importance of the engineering profession, using this term in the broadest possible sense. That the profession is not appreciated as it should be is not the fault of the public, but the fault of the engineers themselves. The public is willing to learn, but must have a teacher, and the local engineering societies should assume the position of instructor. One of the first lessons ought to be the establishment of a code of ethics. The societies owe this to themselves as well as to the general public. The subject has been brought before at least one of the national societies and has been before several of the local societies, including our own, but so far nothing tangible has resulted. It is time some organization took the lead in making an effort in this direction, and the suggestion is made that the Civil Engineers' Club of Cleveland assume such leadership and gain the credit of carrying the matter to completion.

A few words from a paper read before the Boston Society, March 15, 1893, by Mr. A. W. Locke, are as applicable now as then:

"If they want things they must demand them and take means to enforce their demands. They should act together for their own common good. The engineering society should not be for the sole purpose of exchanging experiences, but rather to strengthen the position of its members and to uphold their dignity and to influence public opinion for their benefit. On all public questions affecting the interests of engineers, the society should act as a unit and make itself heard and felt. The requirements for full entrance should be severe and high, and the society should establish for

its members their minimum fees and regulate, so far as practicable, their relations to each other and to their clients. It should throw over them a mantle of protection and discourage the process by which the client is enabled to crowd down the fees by inducing engineers to bid against each other on the same work.

"By the enforcement of some such improvements as are above set forth in the relations of the engineer to his client, both parties would be benefited, and also the whole community would reap the advantage of better work and, in many cases, a more economical use of money."

Let us give our time and efforts freely to the best interests of the Civil Engineers' Club of Cleveland. Let us have in mind Section 2 of our Constitution, "The objects of the Club shall be the professional improvement of its members, the encouragement of social intercourse among them and the advancement of engineering science." Let us make this Club a model for other local societies, and let us be the first local club to have a creditable home of our own, suited to our professional and social needs in every way. We can do this if we will; let us say we will. Let us not only hope and pray, but *work* to this end.

In conclusion, I wish to thank the members of the Club for the honor bestowed upon me and to ask that the same kindly support and courtesy be extended to my successor in office as has so freely been given to me.

ANNUAL MEETING, MARCH 14, 1899.—The meeting was called to order at 8 o'clock; President Osborn in the chair. Present, thirty-five members and two visitors. The chair appointed Messrs. John N. Coffin and John L. Culley tellers to canvass the ballots for members and for officers for the ensuing year. The minutes of the last meeting were read. Mr. Hyde disclaimed making one remark as recorded, and, on motion of Mr. Ritchie, the sentence was struck out.

The Executive Board recommended to ballot the names of Howard P. Fairfield and Ernest Starr Jackson, applicants for admission as active members. It reported the following resignations as accepted: Wendell P. Brown, Chas. F. Mabery, Harry B. Strong, E. Ernest Rose, Valentine S. Ives, Sidney H. Short, active members, and Wm. C. Jewett, corresponding member.

Three active members, John P. Leeper, Chas. E. Webster and W. H. Bone, have been transferred to corresponding membership. Mr. S. T. Dodd has been elected by the board to fill the vacancy caused by the resignation of Ralph A. Harman as Director.

Mr. Harry L. Andrus has been appointed by the board as advertising agent.

The board announced the death of Mr. Hiram Kimball, which took place on the 9th instant.

Under the head of "Correspondence," a report from the Engineers' Club of Cincinnati was quoted from, indicating the amount of work done by that Club during the past year. A letter was read from Mr. A. J. Robinson, Secretary of the Association of Civil Engineers and Surveyors of Oklahoma Territory.

The President then read the annual report of the Executive Board, which was followed by the annual reports of the Secretary, Treasurer and Librarian. On motion, these reports were accepted.

Mr. A. L. Hyde read the annual report of the Program Committee, which, on motion, was ordered accepted and filed.

The President then read the tellers reports and announced the election to active membership of Allan Wadsworth Carpenter, and of the entire ballot for officers,—viz, Jared A. Smith, President; John W. Langley, Vice-President; Arthur A. Skeels, Secretary; John N. Coffin, Treasurer; Wm. E. Reed, Librarian; Jos. R. Oldham and Wm. B. Hanlon, Directors.

The announcement was greeted with applause.

The report of the Committee on Federation, appointed at the last meeting, was presented by Dr. Howe. It consisted of the minutes of the Joint Committee, and contained nine sections, providing for the joint occupation of rooms for two years by the several Clubs, and for a House Committee, which shall have sole charge of all details of the selection and furnishing of rooms, and expenditure of joint funds in maintaining them; providing also for the manner of making assessments upon the several Clubs.

Mr. Ritchie, seconded by Mr. Culley, moved the adoption of the report. A second reading of the report was called for and discussion followed as the reading proceeded. The discussion was participated in by Messrs. Hoit, Warner, Hyde, Searles, Coffin, Parmley and Bowler. Dr. Howe answered many questions and defended the report of the committee. Dr. Langley then moved that the debate be closed and a vote on the question be taken. Carried. The report was adopted.

Dr. Howe moved that this Club appropriate, out of the general fund, its apportionment, a sum not to exceed three dollars per capita, to be used by the House Committee in furnishing the rooms. Seconded and carried without debate.

THE CHAIR.—How shall the members from this Club of the House Committee be appointed?

Mr. Mordecai moved that the President make the appointments. Carried.

The President made appropriate remarks upon the death of Mr. Hiram Kimball, and Mr. Ritchie moved the appointment of a committee to prepare and report suitable resolutions upon the death of Mr. Kimball. Seconded and carried. The chair appointed Messrs. Ralph A. Harman, Horace E. Andrews and Jason A. Bidwell.

Mr. Warner moved that a vote of thanks be extended to the retiring officers for their services during the past year. Carried. Mr. Warner then made some complimentary remarks upon the manner in which the work of the Secretary's office had been conducted during the year. Mr. Osborn, on behalf of the Executive Board, seconded the remarks of Mr. Warner.

The President then delivered his annual address, entitled "The Civil Engineers' Club of Cleveland; a Review of its Past, with Some Suggestions Regarding its Future." The address was received with applause.

The newly elected officers were severally called upon to address the Club. Brief and pertinent remarks were made by Col. Smith, Prof. Langley and Messrs. Skeels, Coffin and Reed.

Dr. Howe alluded to the fact that some of the oldest members in the Club find themselves in such circumstances as to be unable to pay their dues, which are several years in arrears. Under the Constitution the Executive Board has no option except to drop such members. He therefore moved that the Executive Board be authorized to remit the annual dues

of such members, not to exceed five at any one time, as in their discretion they may see fit. Seconded by Mr. Reed and carried.

Mr. Mordecai moved that the very able address of the President be referred to the Executive Board to take such action in regard to it as they may see fit. Carried.

Mr. McLouth alluded to the fact that our present high schools are very much crowded, and advocated the establishment of at least one high school on engineering and scientific lines. He hoped that some meeting of the Club may be held at the Central Manual Training School, where the subject might be more thoroughly discussed.

At half-past ten the Club adjourned.

WILLIAM H. SEARLES, *Secretary*.

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR ENDING
FEBRUARY 28, 1899.

To the Executive Board of the Civil Engineers' Club of Cleveland:

GENTLEMEN:—I have the honor to present the following report on the membership and business of the Club for the fiscal year ending February 28, 1899:

MEMBERSHIP.

At the beginning of the year the membership consisted of 151 active members, 22 associates, 13 corresponding and 5 honorary members, a total of 191. The accessions by election have been 12 active and 1 associate member. The losses by resignation have been 11 active and 1 corresponding member, and by forfeiture 10 active, 2 associate and 1 corresponding member. There have been 7 transfers made from active to corresponding membership. As the result of these changes the membership of the Club on February 28, 1899, consisted of 135 active, 21 associate, 18 corresponding and 5 honorary members, a total of 179. The net loss in numbers is, therefore, 12. The pecuniary loss to the treasury is \$235 in the delinquent dues of those who have forfeited their membership.

BUSINESS.

Following is the statement of the receipts and disbursements for the year ending February 28, 1899:

<i>Receipts:</i>		GENERAL FUND.	
Balance on hand February 28, 1898.....			\$160.18
Dues of current year.....	\$1,607.50		
Dues of past years.....	251.00		
Subscription to JOURNAL.....	3.00		
Advertising	48.00	1,909.50	
			\$2,069.68

<i>Disbursements:</i>	
Publication of JOURNAL.....	\$219.75
Printing (including Annual Register).....	169.91
Stationery	31.50
Postage and express.....	52.15
Stenographer	64.00
Salaries	252.40
Certificates of membership.....	8.00
Furniture	102.00
Case Library memberships.....	142.00
Rent of Rooms.....	135.00

Social account (including deficit on banquet).....	\$230.55	
General expenses (collector).....	5.40	
	<hr/>	\$1,412.46
Balance in hands of Treasurer.....		657.22
		<hr/>
		\$2,069.68

LIBRARY FUND.

Receipts:

Balance on hand February 28, 1898.....		\$23.72
Subscriptions collected by A. L. Hyde, Librarian.....	\$175.00	
Subscriptions collected by W. E. Reed, Librarian.....	55.00	230.00
	<hr/>	<hr/>
		\$253.72

Disbursements:

Additions to library.....	\$148.60	
Balance in hands of Treasurer.....	105.12	
	<hr/>	<hr/>
		\$253.72

PERMANENT FUND.

Receipts:

Balance on hand February 28, 1898.....		\$722.90
Fees of current year.....	\$60.00	
Interest on fund deposited.....	29.40	89.40
	<hr/>	<hr/>
Balance in hands of Treasurer February 28, 1899...		\$812.30

SUMMARY OF BALANCES.

General Fund.....	\$657.22
Library Fund.....	105.12
Permanent Fund.....	812.30
	<hr/>
	\$1,574.64

Respectfully submitted,

WILLIAM H. SEARLES, *Secretary*.ANNUAL REPORT OF THE EXECUTIVE BOARD FOR THE FISCAL YEAR
ENDING FEBRUARY 28, 1899.

[Presented at the annual meeting, March 14, 1899.]

The Executive Board, in compliance with the Constitution, presents its report for the year ending February 28, 1899:

The board has held twelve sessions during the year, with an average attendance of seven members. The business of the Club has been regularly conducted according to a code of rules adopted at the beginning of the year. Monthly reports have been submitted by the Secretary, Treasurer and Librarian, showing the condition of the Club in all particulars.

Only about one-third as many applications for membership have been received this year as last, which, taken with the usual losses, has resulted in reducing the total membership to about what it was two years ago. No change has been made in the policy or usages of the Club during the year. Seventeen meetings have been held, with an aggregate attendance of 425 members and 131 visitors, or an average of 25 members and 8 visitors. The largest meeting of the year was held on April 12, at Case School, with an attendance of 41 members and 16 visitors. The technical work of the Club has been well sustained in the number and character of the papers read and in the discussions following. The practice of serving a simple lunch after each meeting has been continued with the effect of cultivating a mutual

acquaintance and interest among such as attend, though not increasing the attendance so much as could be desired.

The carefully devised plan, submitted a year ago, for obtaining a house for the Club did not meet with the cordial support that would have made it a success, and it had to be abandoned for the present. The recent movement in favor of rented rooms has received more encouragement, so that the prospect is good for seeing the Club suitably provided for in this respect. Should the Club take such rooms as it ought to have and can pay for and suitably furnish, new life and interest would be imased and a vigorous growth would undoubtedly result.

The library is in much better shape than ever before, and is well cared for under the arrangement made with Case Library. Considerable additions in the way of valuable technical books have been made during the year, both by purchase and gift. For the coming year at least the connection with the Case Library will be continued, so far as the joint use of the libraries is concerned.

The addition of new societies to the Association and the enlarged circulation have materially reduced the assessments upon this Club for the support of the JOURNAL. The cost to us for the last four quarters, including the first quarter of 1899, is \$262.25, and this is reduced to \$214.25 by what we receive from advertisements. This brings the net cost to us of the JOURNAL to \$1.27 per member.

An agent has recently been appointed to solicit advertisements in Cleveland for the JOURNAL, through which means, it is hoped, the JOURNAL will soon become self-supporting, so far as our share in it is concerned. This matter is earnestly commended to the favorable attention of all members and friends of the Club who have occasion to advertise. Relieved of this item of expense, the Club would devote the funds so saved to improving the library and other appointments of the Club.

For further particulars reference is made to the several official reports herewith submitted.

By order of the Executive Board.

FRANK C. OSBORN, *President*.
WM. H. SEARLES, *Secretary*.

TREASURER'S ANNUAL STATEMENT, MARCH 7, 1899.

Receipts:

1898.			
March 16.	From former Treasurer:		
	Account Permanent Fund.....	\$722.90	
	" General Fund.....	160.18	
	" Library Fund	23.72	
		<hr/>	\$906.80
	From Society for Savings, account Per-		
	manent Fund interest.....	\$29.40	
	" Secretary, account Permanent Fund	60.00	
		<hr/>	89.40
	" Secretary, account General Fund...	\$1,909.50	1,909.50
		<hr/>	
	" Mr. Hyde, Librarian, account		
	Library Fund	\$175.00	
	" Mr. Reed, Librarian, account		
	Library Fund	55.00	230.00
		<hr/>	
			\$3,135.70

Disbursements:

Secretary's vouchers Nos. 1 to 51, inclusive, account General Fund.....	\$1,412.46	
Secretary's vouchers Nos. 1 to 10, inclusive, account Library Fund.....	148.60	
	<hr/>	\$1,561.06

Balances on hand:

Permanent Fund in Society for Savings..	\$812.30	
General Fund in Commercial National Bank	657.22	
Library Fund in Western Reserve National Bank	105.12	1,574.64
	<hr/>	\$3,135.70

Approved:

JOSEPH R. OLDHAM,
Finance Committee.

WALTER MILLER,
Treasurer.

A REGULAR meeting of the Club was held at Case Library, May 9, 1899. Meeting was called to order at 8.15 P.M. by President Jared A. Smith. Present, twenty-three members and four visitors. Minutes of meetings of March 14, April 11 and 25 were read and approved. Application for active membership of T. B. Van Dorn was read.

A letter from Mrs. Curtiss was read in which she thanked the Club for the sympathy expressed at the time of the death of Stiles H. Curtiss, a member of the Club.

Resolutions were then read by Mr. Jason A. Bidwell on the death of Hiram Kimball. Dr. J. W. Langley moved adoption of report. Seconded and carried.

Resolutions were then read by Dr. Cady Staley on the death of Stiles Henry Curtiss. Mr. Robert Hoffman moved that the report be adopted. Carried.

Dr. Charles S. Howe, of the House Committee, reported progress and informed the Club that the new quarters would be ready in about two weeks. Mr. F. S. Barnum, of the Banquet Committee, recommended dropping banquet and having a "house warming" in the new rooms instead. Moved by Prof. C. H. Benjamin that the recommendation of the Banquet Committee be adopted. Seconded by Prof. R. H. Fernald and carried.

The President appointed Mr. A. L. Hyde and Mr. H. P. Fairfield tellers to canvass the ballots for transference of \$480 from permanent fund to general fund.

Vice-President J. W. Langley was called to the chair, and Dr. C. S. Howe moved to proceed with the discussion. Seconded by Col. Jared A. Smith and carried.

The discussion on the "Desirable Qualifications in Technical School Graduates" then followed and was taken part in by Messrs. Jared A. Smith, A. W. Johnston, E. P. Roberts, Cady Staley, F. S. Barnum, C. O. Palmer, Chas. H. Benjamin, C. S. Howe, J. W. Langley and, by letter, Chas. E. Webster.

The arguments were one-sided, all the gentlemen practically agreeing upon the points of which the following is a brief outline: For a man in scientific pursuits and who expects to rise in his profession a technical education is absolutely necessary. He may acquire it by his own efforts

and be a self-made man, but the technical school will save him much valuable time and make his rise more rapid.

A technical graduate should be well trained in mathematics, especially descriptive geometry. Should know how to draw neatly, intelligently and accurately. He should know how to handle all instruments and tools. He should know where to find things and how to use them. In short, he should have a general knowledge of useful things which are difficult to learn outside of school and depend upon practical work to learn those details which can best be learned in the shop or field.

A technical graduate is not expected to be as valuable to his employer for a year or two as the man who has spent four years in actual work, instead of study, but at the end of a few years the graduate will overtake and go ahead of the other.

The President then read the teller's report, which was unanimously in favor of the transference of \$480 from the permanent fund to general fund, and such transference was ordered. Meeting adjourned at 10.20 P.M.

A SEMI-MONTHLY meeting was held in Case Library, May 23, 1899. Meeting called to order by Col. Jared A. Smith at 8.10 P.M. Present, twenty-one members and eleven visitors. The paper of the evening, entitled "Concrete Fireproofing," was read by Mr. F. S. Barnum. After the paper was read it was discussed by Messrs. Briggs, Smith, Barnum, Hopkinson, Herman, Hyde, Osborn, Eisenman and Dodd. Meeting adjourned at 10.10 P.M.

ARTHUR A. SKEELS, *Secretary*.

Engineers' Club of St. Louis.

490TH MEETING, MAY 3, 1899.—The Club met May 3, 1899, at 8.20 P.M.; with Vice-President Nipher in the chair. The minutes of the 274th meeting of the Executive Committee were read. Sixteen members and one visitor were present.

Mr. Pitzman addressed the Club in regard to subscribing to the World's Fair Fund. He said that he had been requested by the Finance Committee of the St. Louis World's Fair to take the necessary steps to secure stock subscriptions from the engineers and surveyors of the city to the capital stock of the corporation to be organized under the act of Legislature for the purpose of celebrating the centennial anniversary of the Louisiana Purchase, and as he thought the great historical event of the Louisiana Purchase should be celebrated in a manner commensurate with the importance of St. Louis, the largest city in the Louisiana Purchase, and as the holding of an exposition will give great opportunities to the engineers and greatly benefit their profession, he moved that the chairman be authorized to appoint a committee of three, to solicit subscriptions from the members of the Club. The motion was carried, and the chairman appointed as members of the committee Julius Pitzman, W. H. Bryan, and E. R. Fish.

Mr. John A. Laird described the hydraulic system that will be used for moving the gate valves at the Baden Station. The system is now in use for moving the valves already in place. When the station is completed, there will be eight 36-inch and four 30-inch valves, each of which will be moved by a piston worked by hydraulic pressure in a cylinder. Oil is used as the medium for transmitting the pressure, and it is circulated by a small direct

acting steam pump. In order to save space and piping it was decided to adopt a one-pipe system, in which one pipe acts for both pressure and exhaust. There are about 600 feet of $\frac{3}{4}$ -inch pipe in the system, and the pressure required to circulate the oil through the entire length varies from 25 to 50 pounds per square inch, depending upon the temperature. It sometimes takes 100 pounds pressure to start a valve, and after being started 30 to 40 pounds to lift it. The valves require no pressure to close them; but 30 pounds is put on to seat them. It is impossible to drop a valve, as the friction of the oil in the $\frac{3}{4}$ -inch pipe will only let it settle down slowly. No governor is used on the pump. Stereopticon views were shown of the general arrangement of pump and cylinders for moving the valves, details of the two regulating valves, the main valves and cylinders, and several of the different valves in place.

The Secretary read an abstract of a paper by Messrs. John F. Wixford and S. B. Russell on "Chemical Tests of Cement."

Professor Nipher made a few remarks on gravitation in cosmical masses of gas. When a nebula loses heat by radiation into external space, that heat, so far as can be discovered, never returns. It travels outward with the speed of light, and the imagination is lost in conjecturing what really becomes of it. The nebula contracts, as might be expected. It gravitates towards its center of gravity. It does not contract for the same reason that a gas bag under atmospheric pressure would contract when cooled. There is no external pressure on a nebula. It apparently pulls itself together by gravitation. The remarkable thing is that the nebula becomes hotter in the operation. The operation might be described as follows: The nebula loses heat. It does work on itself. It becomes warmer. It is, however, very questionable whether it is correct to say that the gas does work on itself when gravitating together. The nature of gravitation is absolutely unknown. But it seems probable that some external and unknown system is doing work on the gas when it is gravitating into smaller volumes, or that it is being gravitated. But the action is very different from an ordinary compression. The action is on each individual atom or molecule. Nothing could be more wonderful, when closely considered, than the fact that equal masses of steam and ice have equal weights.

J. H. KINEALY, *Secretary pro tem.*

491ST MEETING, MAY 17, 1899.—Meeting was called to order at 8.20 P.M.; President Colby presiding. Twenty-five members, no visitors, were present. The minutes of the 490th meeting were read and approved. The minutes of the 275th meeting of the Executive Committee were read. The names of E. S. Pillsbury, S. B. Way, C. N. McFarland and F. C. Faust having been recommended by the Executive Committee, were balloted for and all declared elected members of the Club.

The committee appointed to draw up resolutions on the death of Winthrop Bartlett made its report, which was accepted. The resignation of Mr. Richard McCulloch, as a member of the Board of Managers of the Association of Engineering Societies, was read and accepted. On motion, it was voted to make the election of his successor special order at next meeting.

Prof. F. E. Nipher then gave a talk on the elongation of steel bars as a function of the temperature and stress. Professor Nipher gave the equation, showing the relation of the several quantities, and discussed the equation, showing graphically the way in which the quantities varied. As data on

which to base the truth of the equation is very scant and covers only a comparatively low range of temperature, the agreement between theory and practice is not satisfactory. Special reference was made to the application to welded street railway track.

The discussion following was participated in by Messrs. Holman, Connor, Kinealy, Russell, Robert Moore, Dunaway.

Mr. Colby referred to the presence of Mr. E. L. Corthell in the city, and the plan he is advocating of having an American engineering exhibition at the Paris Exposition. One or two other plans in this connection were mentioned.

There being no further business, the meeting adjourned to another room where lunch was served.

E. R. FISH, *Secretary*.

Montana Society of Engineers.

A SPECIAL meeting of the Society was held in the Art Room of the Public Library in Butte, Montana, on May 13, 1899, Meeting called to order at 9 o'clock P.M.; President Eugene Carroll in the chair. Mr. C. D. Vail acting as Secretary *pro tem*. After reading and adoption of the minutes of the preceding meeting, held in Helena, Messrs. F. W. Blackford and Samuel Barker, Jr., were appointed tellers to canvass the ballots. It was found that Messrs. Arthur W. Catlin, Oscar C. Finkelnburg and William M. McClean had been elected members of the Society, and that the proposed amendment to Article V, of the By-laws, had been carried unanimously. The principal change by this amendment being the introduction of a new section, as follows:

"Section 7. It shall be the duty of the Secretary, without further authority from the Society, to drop from the mailing list of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, at the beginning of each year of the JOURNAL, the name of any member who has not paid his dues for the preceding year, and the Secretary shall immediately call the attention of such member to this section."

The Committee on Charge of Headquarters of the Society from Helena to Butte reported and recommended amendments for the Constitution necessary to such change. The report was accepted and the Secretary instructed to prepare ballots to be cast at the next regular meeting.

An interesting letter was read from Prof. A. M. Ryon, congratulating the Society on the passage of the bill regulating the measurement of water. The present labor trouble among the builders in Butte was discussed.

No further business appearing, the meeting adjourned.

A. S. HOVEY, *Secretary*.

Boston Society of Civil Engineers.

BOSTON, MASS., APRIL 19, 1899.—A regular meeting of the Boston Society of Civil Engineers was held in Chipman Hall, Tremont Temple, at 8 o'clock P.M.; fifty-four members and visitors present.

President C. Frank Allen, on assuming the chair, expressed his appreciation of honor conferred upon him in the election to Presidency of the Society.

The record of the last meeting was then read and approved.

Messrs. Walter E. Noble and Frank T. Westcott were elected members of the Society.

Professor Swain proposed in writing the following amendment to By-law 5: For the second paragraph substitute the words, "Of the candidates for any office, the one having the largest number of votes shall be elected. If two candidates for any office receive the same number of votes, the meeting shall proceed to ballot for such office between these two candidates, a majority of the votes cast being required to elect."

The Secretary reported for the Board of Government that it had appointed the following special committees of the Society:

On Quarters—Desmond FitzGerald, E. W. Howe, C. Frank Allen, E. W. Bowditch and Hezekiah Bissell.

On the Library—F. L. Fales, C. M. Saville, F. P. McKibben, F. H. Fay and A. D. Fuller.

On Excursions—Leonard Metcalf, H. F. Bryant, C. W. Sherman, D. T. Turner and A. B. Corthell.

Members of the Board of Managers, Association of Engineering Societies—S. E. Tinkham, *ex-officio*, J. R. Freeman, Henry Manley, Fred. Brooks and Dexter Brackett.

A communication was read from Mr. Frank L. Fales, resigning the office of Librarian on account of removal from Boston. On motion, the resignation was accepted and the President requested to appoint a committee of three to nominate a Librarian. The President has appointed as members of this committee Messrs. W. E. McClintock, R. A. Hale and A. D. Flinn.

The President announced the death of Mr. Charles H. Swan, a member of the Society, which occurred on April 17, 1899. On motion, the President was requested to appoint a committee to prepare a memoir.

Mr. William F. Williams was then introduced and gave a very interesting description of the "Construction of the New Bedford and Fairhaven Bridge." The description was illustrated by a large number of lantern views.

Adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., MAY 2, 1899.—A special meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, Boston, at 8 o'clock P.M.

President C. Frank Allen in the chair and one hundred and sixty members and visitors present, including ladies.

Mr. Leonard Metcalf read a very entertaining paper describing a recent trip he had made to Porto Rico, and had thrown upon the screen a large number of lantern views of points of interest which he had visited on the island.

At the close of the reading of the paper Mr. Metcalf answered a number of inquiries with regard to Porto Rico, after which the meeting adjourned.

S. E. TINKHAM, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR MEETING, MAY 5, 1899.—Called to order at 8.30 P.M. by President Percy.

The minutes of the last regular meeting were read and approved.

Application of Mr. Alexander G. McAdie, forecast official, United States Weather Bureau, San Francisco, to become an associate member, was read and referred to the Executive Committee.

Mr. Franklin C. Prindle, civil engineer, United States Navy, addressed the members on the subject of "Dry Docks, Stone *vs.* Wood," which was discussed, some facts about the Mare Island stone dry dock and its cost being stated by the Secretary.

A vote of thanks by the Society was passed for Mr. Prindle for his courtesy in entertaining the request to address the members on a subject which has aroused such general interest.

Adjourned.

OTTO VON GELDERN, *Secretary.*

Engineers' Club of Cincinnati.

106TH REGULAR MEETING, CINCINNATI, O., MAY 18, 1899.—Dinner was served at 6.15 P.M.; seventeen members and eleven visitors being present. The regular meeting was called to order at 7.25; with President Hazard in the chair.

Minutes of the meeting of April 20 were read and approved.

On ballots being taken, Messrs. C. H. Davidson and Wm. E. Green were elected associate members.

The committee appointed to prepare a memoir of Fred. C. Weir, who died April 1, presented a sketch of the life of Mr. Weir, which was ordered received and entered on the records of the Club.

Mr. John F. Earhart, of the firm of Earhart & Richardson, color printers and lithographers, read a very interesting and instructive paper on the subject of "Color."

The program for the evening had been arranged by the President, and, in addition to the paper with which Mr. Earhart so kindly favored the Club, he had invited a few friends possessed of musical talent, who entertained the Club with vocal and instrumental selections both previous to and after the reading of Mr. Earhart's paper, which proved quite a pleasing diversion and addition to the social features of the meeting, and to whom, as well as to Mr. Earhart, the thanks of the Club were voted.

J. F. WILSON, *Secretary.*

ASSOCIATION OF ENGINEERING SOCIETIES.

VOL. XXII.

JUNE, 1899.

No. 6

PROCEEDINGS.

Engineers' Club of St. Louis.

492D MEETING, JUNE 7, 1899.—Meeting was called to order, at 1600 Lucas Place, at 8.20 P.M.; President Colby presiding. The minutes of the 491st meeting were read and approved. The minutes of the 276th meeting of the Executive Committee were read. The name of O. J. Barwick was proposed for membership. Nominations for member of the Board of Managers of the Association of Engineering Societies were asked for, and W. A. Layman, S. E. Freeman and W. L. Garrels nominated. Messrs. Bennett and Trepp were appointed tellers and announced that Mr. Layman was elected, having received 13 out of 21 votes cast.

Prof. J. H. Kinealy then gave a talk on the Pohle Air Lift Pump. The action of the pump was illustrated by means of a small model. As there is but little literature from which to obtain data for designing, it was necessary to make a lot of experiments, and for this purpose model pumps were made of different dimensions and a series of experiments conducted. The methods of making these experiments were explained and the results given, being illustrated by curves.

Several formulæ were given and discussed. The determination of certain constants, however, is still necessary, as the formulæ and practice do not agree very well. Experiments on full-sized wells are necessary to secure data for the correct determination of these constants.

Mr. Edw. Flad made some remarks on the Pohle pumping plant at the Anheuser-Busch Brewery.

There being no further business, the meeting adjourned to another room, where lunch was served.

E. R. FISH, *Secretary*.

Montana Society of Engineers.

THE regular monthly meeting of the Society was held in Helena, Mont., on June 10, 1899. Meeting called to order at 8.30 P.M.; Mr. James S. Keerl in the chair. The minutes of the preceding meeting were read and approved. The proposed amendment to the Constitution changing the headquarters of the Society to Butte was informally and freely discussed, all agreeing that this change was advisable. Since, through the absence of the Secretary, ballots had not been sent out, the Secretary was instructed to send out ballots to be canvassed at the July meeting.

The sad information of the accidental death of Mr. Henry C. Relf, a member of the Society, was announced. Mr. Relf was a resident engineer for the Northern Pacific Railway Company. While inspecting a "wash-out" on said railway near Plains, Mont., on June 9, he slipped and fell into the rapids of the Clark's Fork of the Columbia River and was drowned.

Messrs. Forrest J. Smith, Finlay McRae and Walter S. Fortiner were appointed to prepare resolutions to be published and transmitted to relatives and acquaintances, and it was recommended that a committee be appointed at the July meeting to prepare a memoir of the deceased.

Mr. Relf was thirty-six years old. He was engaged in the engineering department of the Northern Pacific Railway continuously from 1880 to 1888, being chiefly engaged in construction work upon the main line and branches. He was assistant engineer for the Union Pacific Railway Company from 1888 until 1891, and in the last-mentioned year was engineer and inspector of sewer construction for the city of Denver, since which time he has been assistant engineer for the Northern Pacific Railway Company, with headquarters at Tacoma, Washington. The Committee upon Resolutions presented same, and after their adoption the meeting adjourned.

A. S. HOVEY, *Secretary*.

Resolutions.

HELENA, MONT., June 10, 1899.

WHEREAS, It has pleased an all-wise Providence to remove from our midst our late member, Henry C. Relf, and

WHEREAS, It is but just that a fitting recognition of his many virtues should be had; therefore be it

Resolved, By the Montana Society of Engineers, that while we bow in humble submission to the will of the Most High, we do not the less regret the loss this organization has sustained by his untimely death.

Resolved, That by the death of Henry C. Relf the Society has lost a member who by his professional attainments and sterling worth had endeared himself to all who knew him, and who, had he lived, was destined to become one of the foremost civil engineers of his time.

Resolved, That the heartfelt sympathy of this association be extended to his family in this the hour of their bereavement; and be it further

Resolved, That these resolutions be spread upon the permanent records of the Society, and that a copy be sent to the grief-stricken family.

FORREST J. SMITH,
FINLAY McRAE,
W. S. FORTINER,

Committee.

Boston Society of Civil Engineers.

BOSTON, MASS., MAY 17, 1899.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, Boston, at 8 o'clock P.M.; President C. Frank Allen in the chair. Fifty-one members and visitors present.

The records of the last meeting, and of the special meeting of May 2, were read and approved.

Messrs. Wm. Church Hawley and Charles Francis Morse were elected members of the Society, and Mr. William L. Miller an associate.

On motion of Mr. Sherman, the thanks of the Society were voted to Mr. Harry P. Nawn for courtesies extended on the occasion of the visit to the Charles River Speedway this afternoon.

The thanks of the Society were also voted to Mr. Austin Cary for his very interesting talk on the "Management of the Forests of Maine," given at the informal meeting of May 10.

Mr. Hale, for the Committee to Nominate a Librarian, reported the name of Andrew D. Fuller, and upon a ballot being taken he was unanimously elected.

The next business taken up was the amendment of By-law 5 proposed in writing at the last meeting of the Society. After considerable discussion, on motion of Mr. French, it was voted to refer the proposed amendment to a committee to report a By-law at the next meeting in proper form to be acted upon. The President appointed as a committee on the proposed By-law Messrs. G. F. Swain, F. P. Stearns and A. H. French.

Mr. Freeman C. Coffin then read the paper of the evening, entitled "Covered Reservoirs and Their Design."

The paper was discussed by Messrs. F. P. Stearns, N. H. Goodnough and F. L. Fuller.

Adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., JUNE 21, 1899.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.50 o'clock P.M.; President C. Frank Allen in the chair. Seventy-three members and visitors present.

The record of the last meeting was read and approved.

Mr. Leon S. Griswold was elected a member of the Society.

The President announced the appointment of the following committees:

To Prepare a Memoir of Charles E. C. Breck, Messrs. J. H. Curtis and Channing Howard.

To Prepare a Memoir of Charles H. Swan, Messrs. H. A. Carson and O. F. Clapp.

The Secretary read the following report:

The committee appointed to draft the proposed change in Section 5 for the By-laws begs leave to report as follows: We recommend that paragraph 2 of Section 5 be amended so that it shall read as follows: "Of the candidates for any office, the one having the largest number of legal votes by letter ballot shall be elected. If the ballot for any office should result in a tie, the meeting shall proceed to ballot for such office between the candidates tied for the first place, a majority of the votes cast being required to elect."

GEORGE F. SWAIN,
FREDERIC P. STEARNS, } *Committee.*
ALEXIS H. FRENCH,

Mr. Brooks asked for an explanation of the meaning of the words "for first place" in the proposed amendment, and after a brief explanation by Mr. French and discussion by Messrs. A. H. Howland, G. E. Howe and F. L. Fuller it was voted to refer the report back to the committee for a further report at a later meeting.

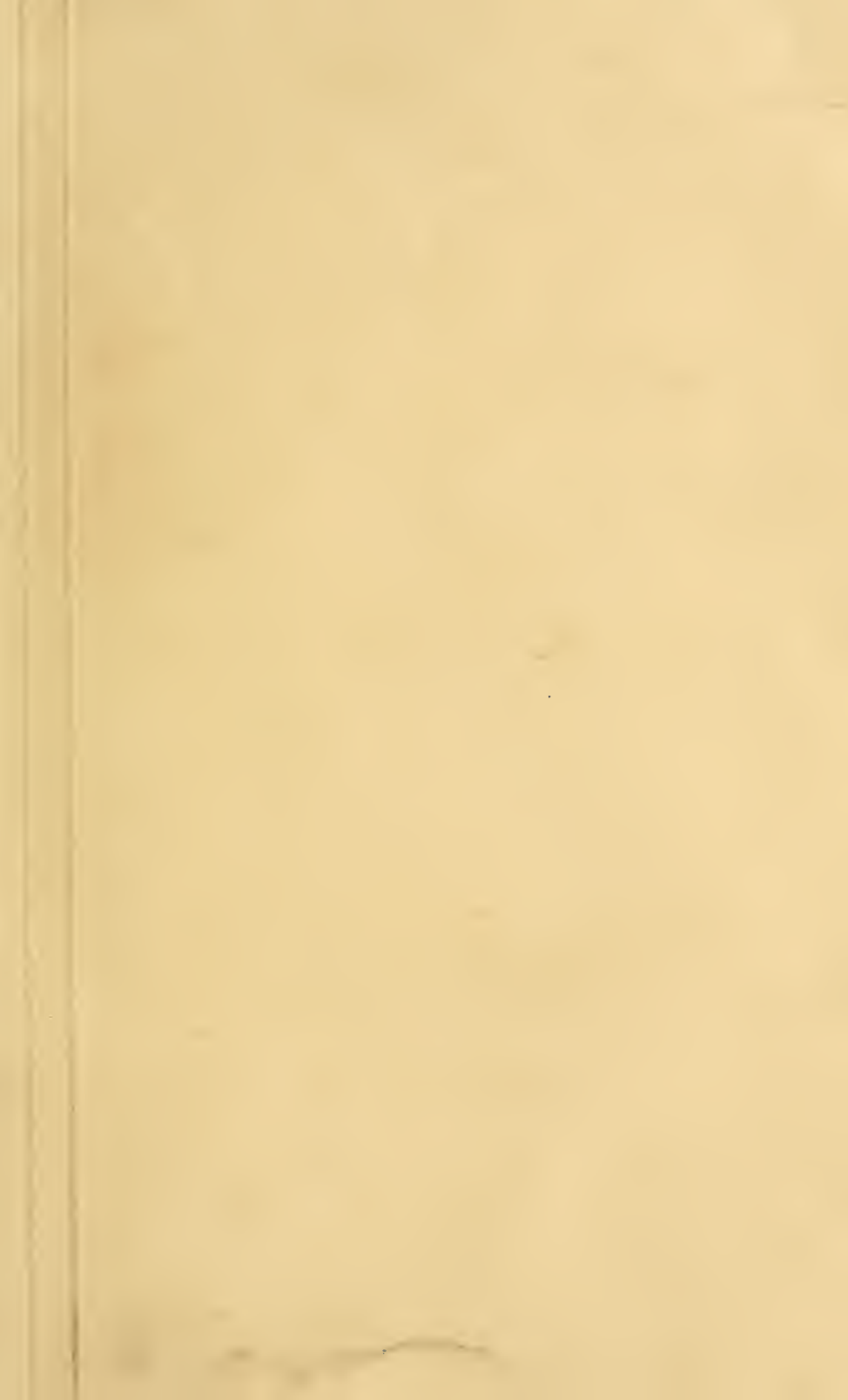
On motion of Mr. E. W. Howe, the thanks of the Society were voted to the New England Gas and Coke Company, to L. J. Hirt, its chief engineer, and to Dr. F. Schniewind for courtesies shown members of the Society this afternoon on the occasion of the visit to the plant of that company recently erected at Everett, Mass.

Mr. Louis J. Hirt, chief engineer of the New England Gas and Coke Company, then gave a very entertaining and instructive description of the engineering features in connection with the construction of the company's plant at Everett, Mass. The description was profusely illustrated by lantern slides.

At the conclusion of the lecture the thanks of the Society were voted to Mr. Hirt for his interesting description.

Adjourned.

S. E. TINKHAM, *Secretary*.



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